polish 4(176)'11
sociological
review
ISSN 1231 - 1413

ŁUKASZ AFELTOWICZ
Nicolaus Copernicus University

KRZYSZTOF PIETROWICZ
Nicolaus Copernicus University

Social Machines and Patterns of Natural Sciences: On Some Implications of Science and Technology Studies[1]

Abstract: We propose new articulation of the differences between the natural sciences and the social sciences. Drawing on science and technology studies (STS) we reconstruct the organizational and cognitive mechanisms of a certain type of natural sciences, one which is referred as laboratory science or high-consensus,rapid discovery sciences. The key features of those sciences crucial for their cognitive and engineering success include:

- experimental reproduction of the studied phenomena in the laboratory;
- laboratory interventions and modifications of the phenomena thus evoked and broadly understood scientific 'tinkering';
- attempts to transfer the artificial arrangements developed in laboratory to non-laboratory settings.

The STS perspective not only helps us to explain the differences in status and effectiveness between the social sciences and the natural sciences. It also allows us to formulate certain general recommendations for the development of the social sciences. We attempt to show that sociologists are able to implement engineering projects in certain domains of social reality, projects involving the creation of closed socio-technical systems—analogous to the ones which are generated by natural laboratory sciences. We refer to those systems as 'social machines' and the proposed research methodology is called 'synthetic methodology'.

Keywords: science, technology, society studies, naturalism–antinaturalism controversy, synthetic metodology, social engineering

Introduction: A Possible Contribution of STS to the Social Sciences?[2]

One of the main problems of social sciences methodology is how to explain the differences between the natural sciences and the social sciences (cf. e.g. Cole 1994a, 1994b; R. Collins 1994; Davis 1994; Stinchcombe 1994). Explanations have largely been suggested within the context of the naturalism–anti-naturalism controversy (e.g. Mokrzycki 1980; Ossowski 1967; Popper 1965). Much attention has been paid to the low effectiveness of the practical applications of social sciences compared with the spectacular technological applications of the natural sciences. It has been quite widely acknowledged that the natural sciences generate not only highly reliable knowledge

[1] This research was funded by a grant "Contemporary social engineering. Innovations in social sciences and natural sciences" (N N116 294938) from the Ministry of Science and Higher Education.

[2] Several fragments of this text are based on the authors' earlier publications on this subject (Afeltowicz & Pietrowicz 2008a, 2008b, 2009).

but also accurate predictions and effective technologies whereas the social sciences mainly generate controversies and unreliable predictions and applications (cf. e.g. Fuchs 1992, 1993; R. Collins 1994).

Three types of explanations of this state of affairs have are recurrent in literature (cf. the slightly different typology proposed by Zybertowicz 1995: 274–276). The first group of explanations is characteristic for traditional philosophy of science. It is based on nassumption that the social scientists do not use the proper research methods, that I the ones that are used by representatives of natural sciences. Therefore they are unable to make quantifications and formulate the laws which govern social reality. The second group of explanations focuses on the ontological properties of social reality and social actors. Firstly, advocates of this group of explanations argue that the phenomena of interest of the social sciences are far more complex than the objects and processes studied by natural sciences (Zybertowicz 1995: 275). Secondly, they also argue that social phenomena, as opposed to physical ones, are historically mutable. For example, sociological explanations intervene in social reality and change objects of study because social actors modify their behaviour in response to the propositions which sociologists formulate (cf. Ossowski 1967: 254–255; Merton 1948, 1968: 447). Thirdly, they stress that social scientists deal with agents endowed with autonomy, subjectivity or free will and therefore cannot possibly formulate deterministic laws. Explanations which point out the ethical problems impeding the application of experimental methods also belong in this group (Zybertowicz 1995: 274–275). In other words, these explanations focus on the various qualitative differences between social and natural reality. The third group of explanations focuses on organizational and institutional factors, e.g. the fact that the social sciences are insufficiently funded compared with the natural sciences. It also points out that the social sciences are fragmented and multi-paradigmatic, that they have their own specific organizational culture and that they are submitted to the different mechanisms of social control (cf. Fuchs 1992, 1993; Collins 1994; Knorr-Cetina 1999; Sojak 2004: 25–41, 61–70).

These standard, recurrent explanations have been challenged by science and technology studies (STS) (cf. Knorr-Cetina & Mulkay 1983; Pickering 1992), and especially by anthropology of science (cf. Knorr-Cetina 1981; Latour 1987; Latour & Woolgar 1979; Lynch 1985). Traditional explanations of the so-called social sciences "lag," "backwardness" or "underdevelopment" tacitly assumed the natural science model formulated by traditional philosophers of science as reference point for social sciences development (Popper 1959; Sneed 1979; Carnap 1995). This model' focused on science conceptualized as scientific knowledge and intellectual activity. Meanwhile anthropologists of science and other STS representatives usually conceptualize science as a form of pragmatic actions, e.g.: designing and building of efficient and reliable research instruments and experimental machines, tinkering with those devices (comp. the concept of *bricolage*: Levi-Strauss 1966: 12–22), laboratory negotiations between scientists, generating, processing and comparing paper inscriptions and other external representations. STS points to those everyday workbench activities as factor which are decisive for the cognitive-engineering success of natural sciences. Hence, STS allow us to approach the problem of the status of the social sciences and re-define the differences between these sciences and the natural sciences in a new way.

Bruno Latour, a French anthropologist of science, was one of the researchers who attempted to draw from STS recommendations for cosial sciences . In his paper "When Things Strike Back: A Possible Contribution of 'Science Studies' to the Social Sciences" (Latour 2000), he argues that social scientists have adopted the philosophical vision of natural science methodology. Therefore, some of them have taken the naturalist road, striving to imitate patterns of natural sciences, whereas the rest have tried to build the identity of the social sciences in opposition to the philosophical vision of the natural sciences. Unfortunatly, neither of these groups has attempted to revise philosophy of science's assumptions concerning the natural science patterns. According to Latour, many social scientists have refrained from any attempt to explain science sociologically because too they themselves have perceived sociological explanations of practice asrefutation or delegitimization. Therefore they have not tried to explain the objective status and effectiveness of natural science for fear of the direct consequences for the very status of the social sciences which glean part of their legitimacy from the authority of the natural sciences. Meanwhile, rather than questioning the status and objectivity of science, the sociological explanations of science developed within the STS framework founded it on a completely different ground than those of standard philosophy of science. What is more, by demolishing the philosophical notions of how the natural sciences function, STS have pointed out the elements which the social sciences ought to include in their analyses in order to explain social phenomena. For example, they should not ignore such material and technological factors as cars, stones, technical infrastructure, or such scientifically-represented natural objects as microbes, global warming or neutrinos, all of which Latour grants status of actor . This approach has significant consequences, both ontological and political (Latour 2004). Although we think that Latour's proposal a important and although we acknowledge his understanding of the naturalism-anti-naturalism debate, we wish to draw the reader's attention to the direction of analysis of social sciences which STS opened up for us,which Latour and many other gahe not taken. We shall focus primarily on the role of the laboratory and its expansion.

Taking the findings of anthropology of science as our point of departure, we are going to suggest several general methodological recommendations for the social sciences. We do not intend to present a one-and-only correct set of rules. What we want to do is to articulate a few intuitions concerning so-far unexplored developmental pathways for the social sciences and emphasize the contribution of several projects which are currently being realized at the peripheries of the social sciences. Our objective is to demonstrate that it is quite legitimate, at least from one particular perspective, to encourage sociologists to emulate the patterns of the natural sciences. The real issue is not the one which was the focus of the naturalism—anti-naturalism debate, i.e. "Ought the social sciences imitate the natural sciences at all?"—but the very model of natural science patterns, either tacitly assumed or explicitly accepted as the point of reference. The first part of this article sits within the realm of descriptive methodology (Nowak 2006: 23) and attempts to reconstruct the anthropology of science and STS perspective. For obvious reasons, this presentation is selective and is subordinated to the primary objective of this article. In the second part we will consider the degree to which social scientists are able to adopt the methods and techniques of the natural sciences identified by anthropologists of science. This part will mark a shift from descriptive to normative methodology (Nowak 2006: 23). We shall strive to demonstrate that sociologists, like natural scientists and engineers, are able to construct relatively complex, synthetic systems and then incorporate these systems in the social fabric. We shall call such artificial systems 'social machines' (comp. R. Collins 1992: 191).We also wish to show that, in light of STS findings, the practical application of sociology and social engineering may prove to be one of the decisive factors leading to the progress of the social sciences, including theoretical knowledge.

The Anthropology of Science Perspective

The Importance of Laboratories, Research Instruments and Translation Techniques

According to STS and the anthropology of science, if we are to understand how science works we must focus not on theory and abstract reasoning of scientists but on research, mundane practice. In this approach, the leading role is assigned to the laboratory. Latour (1983) demonstrated that the laboratory community enables effective reduction of complexity of the world and isolation of certain factors. It also helps us to learn how these factors operate and how to manipulate them. On the other hand, laboratory researchers do not deal with Nature, they deal with purified and processed fragments of the natural world, (Knorr-Cetina 1999: 26–32). Many of the phenomena which are the object of interest of physicists or biologists are generated in the laboratory with standardized equipment and procedures. Particular phenomenon can only become the object of scientists' cognitive practices if they have appropriate equipment or standard procedures with which to evoke this phenomon reliably, as need be, within the confines of the laboratory, thus rendering it observable and manipulable (comp. Baird 2004: 12, 16: R. Collins 1994; Hacking 1983). This is beneficial from the cognitive point of view because it allows to speed up the research process by multiplying the number of laboratory trials. This way, we can study artificially generated phenomena more easily than natural objects and processes outside the laboratory which are beyond our control.

Randall Collins points out that by physically manipulating, modifying or finding new applications for research machines, we are able to generate another new phenomena to study. By tinkering with equipment this way we generate new sequences of derivative research machines which Collins calls "instrument genealogies." These new machines allow researchers to observe newer and newer phenomena, leading to streams of scientific discoveries. Consecutive generations of particle accelerators used in high energy physics are fine example (R. Collins 1994: 171).

The role of incription devices and the representations they generate is important here, as Bruno Latour and Steve Woolgar (1979) pointed out. They feine inscription device as 'an item of apparatus or particular configuration of such items which can transform a material substance into a figure or diagram which is directly usable by one of the members of the office space' (Latour & Woolgar 1979: 51). Inscriptions allow researchers to compare temporally or spatially distant phenomena; combine various representations and identify patterns or anomalies. They allow them to capture the chaotic world in the form of laboratory diagrams, tables, graphs etc. Without this translation of phenomena into inscriptions, many processes would evade scientific reflection (comp. Latour 1988; Gooding 2004).

Latour uses the semiotic metaphor of 'translation' to define the transformations which samples, models or other materials with which researchers work undergo (cf. Latour 1999: 24–79). The objects of researchers' interest are usually too complex, intangible or otherwise cognitively inaccessible. Therefore they must be submitted to several transformations before researchers can draw any conclusions about them or compare them (Latour 1983). The most convenient forms of translation are paper inscriptions, drafts, mathematical models or tables (Latour 1988; Latour & Woolgar, 1979). They help to make comparisons and draw conclusions. The problem is that usually to register something in so simple form one must first transform phenomenon many times (Abriszewski & Afeltowicz 2007). Of course the aforementioned techniques for the generation of physical effects in the laboratory are examples of such translation.

Researchers in the laboratory not only make various phenomena cognitively accessible, they also create settings in which they can be manipulated and transformed. These are very important operations. In many disciplines scientific knowledge is generated by manipulating the phenomena under investigation and intervening in these phenomena so as to discover their new attributes and characteristics (Hacking 1983; Latour 1987). Experiments and other laboratory practices are only subordinated to theory to a certain extent. Experiments involve more than just means of falsification, corroboration or confirmation of hypotheses. They are able to autonomously generate cognitive added value. In the specific laboratory setting research activity is a combination of diagram analysis, negotiation among researchers, operations on samples, tinkering with apparatus and physical models, and paper-shuffling (Latour 1987: 254–257).

World Laboratorization and Instrument Expansion as a Source of the Cognitive-engineering Success of Science

The products of laboratory enterprises, be they technological artefact or scientific facts, function only within those domains which have been modified in some manner and subordinated to elements of scientific practice. The spreading of laboratory procedures, devices and techniques to new areas of reality can be seen as an attempt to transform the world into one huge quasi-laboratory. Elements or fields of reality are isolated and submitted to rigorous measuring instruments and laboratory procedures. For example, many modern technologies in order to function require that laboratory conditions be expanded to non-laboratory settings. It is usually impossible to transfer systems and processes developed during laboratory trials and the process of laboratory tinkering beyond the confines of scientific laboratories until the environment into which we intend to transfer our technological innovations starts to resemble the laboratory to a certain extent (Latour 1987: 250). What this means in practice is that we must develop the infrastructure which is essential for the functioning of our innovations and/or transform it into a closed system, isolated from environmental interferences (cf. R. Collins 1992). For example, if cars are to function they need a ramified infrastructure (roads, parking places, petrol stations, service points etc.) but they also need an entire industry which is responsible for the excavation, transport and processing of crude oil (Sojak 2004: 243). In other words, technologies are like trains. They cannot operate without railway tracks (Latour 1983: 155):

> Facts and machines are like trains, electricity, packages of computer bytes or frozen vegetables: they can go everywhere as long as the track along which they travel is not interrupted in the slightest. This dependence and fragility is not felt by the observer of science because 'universality' offers them the possibility of applying laws of physics, of biology, or of mathematics everywhere *in principle*. It is quite different *in practice*. You could say that it is possible in principle to land a Boeing 747 anywhere; but try in practice to land one on 5th Avenue in New York. You could say that telephone gives you a universal reach in principle. Try to call from San Diego someone in the middle of Kenya who does not, in practice, have a telephone. You can very well claim that Ohm's law (...) is universally applicable in principle; try in practice to demonstrate it without a voltmeter, a wattmeter and an ammeter. You may very well claim that in principle a navy helicopter can fly anywhere; but try to fix it in the Iranian desert when it is stalled by a sandstorm, hundreds of miles from the aircraft carrier. In all these mental experiments you will feel the vast difference between principle and practice, and that when everything works according to plan it means that you do not move an inch out of well-kept and carefully sealed networks [Latour 1987: 250].

Anthropology of science widened its appeal for laboratorization of the world to include issues relating to the universality of physical, laws and constants. We can take it for granted that the laws of physics are universal but in order to prove that they are indeed so we must extend our system of instruments and our practices of measurement of crucial physical variables. Ohms, grams or volts can only retain their universal nature if we have a system of measuring instruments which are calibrated, standardized and, above all, disseminated by means of the discipline called metrology (O'Connell 1993; cf. also Latour 1983: 166–167, Latour 187: 247–257).

Without the expansion of scientific instruments and techniques we cannot apply science's technological products. O'Connell gives the following example:

> The US Navy has found that it cannot set up an overseas base simply sending ships, airplanes, bullets and soldiers. None of these can move freely into a new setting unless the Navy first sends the volt, the ohm, the meter, and other standards ahead to prepare the way. As powerful as military equipment appears on TV clips, it is extraordinary fragile without support equipment, and cannot move into new setting for long unless the setting has been prepared by rendering certain variables similar with respect to where the equipment was produced, and stable with respect to time [O'Connell 1993: 163].

The situation is analogous in medicine, electrical industry, electronics, telecommunications or aviation. For example, due to lack of standard inch measurements, electronic systems produced in the Soviet Union did not fit equipment produced anywhere else in the world (Castells 2000: 32). The American armament industry experienced a similar series of fiascos in the 1950s and 1960s precisely because it failed to maintain stringent metrological standards (O'Connell 1993).

As far as dissemination of the products of science is concerned, more than just modification of physical space is at stake. It is also necessary to modify the social practices and the culture within which the innovation is to function. It is often necessary to develop social tacit knowledge resources and essential skills for the operation of the innovations. Culture is formatted to a certain extent according to the schemas of natural science laboratories. At the same time, however, new institutions devolve or old ones are reconstructed. We may say that technological innovations are built into the social tissue or 'socialized, (Brown & Duguid 2003: 86–88, 175).[3] We shall limit our discussion to the simple example of Graham Bell and the telephone he invented. Before his invention could be diffused, it had to be woven into the fabric of culture and social practices. Many potential investors preferred to abide by the traditional and tested solution, the telegraph, largely because people did not know how to use the telephone. Therefore Bell had installed test telephon devices in public places such as hotel reception desks where as many people as possible could see them being used correctly and master the necessary skills (Brown & Duguid 2003: 87–88).

Blurring the Boundaries Between Technological Innovation and Scientific Prediction

Laboratorization of the world is also the key to scientific success in the domain of accurate prediction. As anthropologists of science have demonstrated, prediction is impossible until we extend our laboratories or our instruments:

> Every time a fact is verified and a machine runs, it means that the lab or shop conditions have been extended *in some way*. (…) Forgetting the extension of the instruments when admiring the smooth running of facts and machines would be like admiring the road system, with all those fast trucks and cars, and overlooking civil engineering, the garages, the mechanics and the spare parts. Facts and machines have no inertia of their own (…); like kings or armies they cannot travel without their retinues or impedimenta [Latour 1987: 250].

From this perspective prediction boils down to repetition of standardized laboratory procedures. What is more, the difference between prediction and technological innovation is blurred. Both involve transfer of systems elaborated in the laboratory to the non-laboratory environment and changing certain significant contingencies in the process. Precise predictions concerning the non-laboratory world are practically impossible (Latour 1983). Phenomena which have not been submitted to rigorous research practices and procedures are simply unpredictable—we are only able to predict those processes which we ourselves have 'disciplined' to a certain extent.

From the perspective of anthropology of science the concept of technological innovation as knowledge application is equally problematic. This perspective, articulated time and again in lay discourse and tacitly assumed by many philosophers of science, posits that scientific theory comes first and technological discoveries follow. Meanwhile, as STS and several contemporary philosophers of science have demonstrated, this relation is sometimes reversed. Quite often technological innovations are

[3] Particular attention is paid to modifications and the goodness of fit between technology and society within another branch of STS, Social Construction of Techology (SCOT), cf. Bijker and Law (eds.) (1992); Bijker, Hughes and Pinch (eds.) (1997). It is worth mentioning, for example, the work of Wiebe Bujker (1995, 1997) or Donald MacKenzie (1997, 1998).

developed parallel to, independently of, or in opposition to theoretical conceptions (Baird 2004: 10).

From Theorizing to Tinkering and Back

We may say that the STS perspective 'disenchants' science. Philosophical conceptions traditionally associated research work with abstract reasoning.From the STS perspective, research practice is often a series of quite simple, 'down-to-earth' activities. Science is more than just thinking and writing. One of its key elements is pragmatic tinkering. Often enough, instead of focusing on general theoretic problems, researchers strive to develop reproducible systems which can be transferred to the non-laboratory environment: experimental machines which generate the regularities specified by scientific laws (so-called nomological machines; Cartwright 1999), technologies which produce the physical or chemical effects described in the textbooks, and last but not least, machines which have technological applications (cf. e.g. Knorr-Cetina 1999; Latour 1987). Scientific theory is not completely eradicated from the model proposed by STS but its role is redefined. Its function is no longer central. It appears to be rooted in the researcher's tacit knowledge and know-how (H. Collins 1985) or in laboratory machines themselves (Baird 2004). Abstract theory is now the end product of a long sequence of translations (Latour 1999: 24–79), the effect of the combination of inscriptions and other texts, the reproduction/creation of phenomena and other transformations.

We must bear in mind, however, that not all natural science disciplines are able to extend the laboratory setting efficiently or laboratorize their objects of study. Only some natural sciences can boast cognitive and engineering successes similar to the successes of physics or biology. Instead of speaking about the natural sciences in general it would be more appropriate to focus just on those research fields which Randall Collins called high-consensus, rapid-discovery science (RDS; R. Collins 1994, 1998: 523–569). By RDS we mean research areas where cognitive consensus concerning studied phenomena and methods is considerably high and where, rather than becoming more and more entangled in inconclusive debates, researchers efficiently bring scientific controversies to their closure then attack new problems while viewing the results of previous accepted research as black boxes (Latour 1987: 1–3) and points of departure for further research.

Generalizing somewhat, we may say that the natural sciences operate at least to some extent according to the following scheme:

1. experimental reproduction or creation of phenomena in the laboratory;
2. standardization of experiments so that phenomena can be routinely generated;
3. intervention and modification of the phenomena thus generated and laboratory tinkering in the broad sense;
4. attempts to transfer the systems artificially produced in the laboratory outside the laboratory(e.g. in the form of instruments, machines or technological processes);
5. laboratorization of the world (rendering non-laboratory reality more similar to experimental conditions; developing the necessary infrastructure; transforming

social practices and establishing essential institutions) or/and reproduction of experimental processes within isolated, closed systems.

The Social Sciences from the Perspective of Anthropology of Science—Methodological Recommendations

As we already mentioned, the STS description of how science functions differs in certain important ways from traditional, (post)neopositivist models. Edmund Mokrzycki (1980) demonstrated that generally the proposals of the philosophers of science did not meet with much interest among the natural scientists (to whom they were addressed) although a few significant exceptions can be found (e.g. Hawking 2001: 31). Meanwhile, social scientists adapted these ideas. One may presume that the imitation of 'patterns of empirical sciences' were perceived as promise of rapid advancement of social sciences disciplines. Much of social science methodology can be viewed as an attempt to transfer the patterns of the natural sciences to sociology and related fields. The problem is that what social scientists actually adopted were not the patterns of the natural sciences but rather philosophical images concerning how the natural sciences function. From the STS perspective, (post)neopositivist epistemology has had a paralyzing effect on the research process. Works on standard philosophy of science usually contained a number of postulates on how science ought to be practiced rather than detailed, evidenced-based accounts of actual practices.[4] Philosophers therefore failed to notice various factors which allow researchers to cognitively grasp phenomena, and reduce complexity of problems, and they equated science per se with intellectual activity. Hence the tendency to trivialize experimental practice and overestimate mathematical models. Despite the imputations of standard philosophers of science, anthropology of science does not question the role of theory. What anthropology of science does is point out how many transformations and interventions must be carried out in order to reach this type of abstraction and then be able to relate it to the world. Social scientists were equally unaware of the role of tinkering and other research practices. Seduced by philosophy of science, they strove to reproduce their imaginary model of science. They focused on the construction of theory and instruments without first reducing the complexity of their object of investigation. They tried to discipline their object of investigation conceptually, and only conceptually, with the help of sophisticated instruments and then infer a sociological theory. If they experimented, they did so in order to reproduce certain real-life phenomena, not to evoke certain effects or tinker experimentally (Knorr-Cetina 1999: 36–39). Meanwhile, representatives of natural science RDS do not limit themselves to conceptualizing reality. They try to master reality in and out of their laboratories with the help of material interventions and expansion of experimental practices per se.

---

[4] Things only changed in the 1980s when many philosophers of science began to analyze science empirically and to borrow a number of ideas from sociologists and anthropologists of science. Such philosophers as Nancy Cartwright (1999), Ian Hacking (1993, 1999) or Davis Baird (2004), for example, come to mind.

Although (post)neopositivistictendencies in social sciences methodology have failed this does not mean that we should discard the idea of emulating the patterns of natural sciences altogether. By presenting a different picture of the "patterns of natural sciences," or more precisely, models of specific fields such as RDS, anthropology of science is suggesting rather radical transformation of the existing order of social studies. If we are to adopt this type of patterns, we must make the experiment our key research method, assuming that the purpose of the experiment is not to represent but to reproduce, intervene and reduce the complexity of the studied phenomena (Knorr-Cetina 1999: 36–39). In other words, instead of trying to create experimental situations corresponding with real-life processes in our research endeavour (apparently this is the dominant approach in the social sciences at present), we should try to create artificial social systems in the laboratory or other partly controlled and monitored settings. The goal is not to test hypotheses but to evoke, reproduce and manipulate social effects.

This approach can most aptly be called "synthetic methodology" (Pfeifer & Bongard 2007). It is widely applied in robotics, cognitive science and artificial intelligence. Rolf Pfeifer and Josh Bongard offer the following characterization:

> The synthetic methodology (…) can be characterized by the slogan "understanding by building." If we are interested in how desert ants find their way back to their nest, or how humans walk or recognize a face in a crowd, we build a system—an artefact—that mimics certain aspects of the behavior we wish to study (…).This way of proceeding has proved enormously powerful: because you have to build something that actually works in the real world, there is no way of glossing over details, which is possible when you formulate a theory abstractly [Pfeifer, Bongard 2007: 78]

Therefore, synthetic methodology postulates the need to construct artificial systems encompassing the behaviour in which we are interested and this in turn should help us to understand phenomena which really exist. This was the rationale underlying work on artificial intelligence from the very start: create a thinking machine so as to gain a better understanding of intelligence and cognition. Synthetic methodology can be applied to the social sciences by trying, for example, to build artificial societies (Epstein & Axtell 1996). If we manage to create functional, relatively stable social relations systems in the laboratory, we will also be able to try to infer about the mechanisms of real-life social processes. Applications of synthetic methodology in the social sciences often have the form of computer simulations. Rather than constructing organic systems, researchers who study artificial intelligence so as to gain better insight into the nature of intelligence and cognitive processes construct robots or conduct computer simulations. It is important to remember, however, that these simulations do not consist in mathematically testing models of social reality (for an example of such a simulation see Watts & Dodds 2007); they consist in application of such methods, as neural networks, artificial life simulations or genetic algorithms (Billari, Fent, Prskawetx & Scheffran 2006; Epstein 2005; Gilbert 2004). Although computer simulations are an interesting developmental perspective worth more detailed discussion, we are only signalling their existence here. The focus of this article will be on systems which we shall call "social machines."

Synthetic methodology is basically about seeking to understand social reality by transforming it and about constructing synthetic representations of selected processes. In many cases sociologists are able to construct artificial social systems. These constructions—we can call them "social machines"—are specific, closed social engineering constructs within which social processes and relations take place in routine and predictable ways. These regularities are partly induced by manipulating material elements of the environment in which they are taking place. What exactly can these machines be? Randall Collins explains this quite well. He thinks that the problem with applied sociology is that we do not know how to construct closed social systems. There are very few closed social systems in the social world. The encounter group is a paradigmatic example of a closed system. Social psychologists know how to maintain group pressure so that group members quit smoking or do not stop dieting. They manage to do so because the group itself is a highly concentrated machine whose purpose is to channel emotions and convey emotional energy to its members. The problem is that human emotional 'batteries' go dead when the group adjourns, when the system opens once again to the countless influences of the wider social context (Collins 1992: 191).

The encounter group is a model example of the social machine. It is an artificial, closed system of roles and relations which functions in a reproducible way. We can be sure how the members of the encounter group will behave. We can even encourage them to behave in particular ways as long as we continue to isolate them and as long as psychologists channel their emotions. The artificiality and brittleness of the encounter group is most obvious when it opens to the impact of wider social processes. These will eventually lead to the group's disintegration. Psychologists and micro-sociologists are familiar with many processes and outcomes which can only be evoked, maintained and predicted in "experimental conditions." We must remember, however, that the products of the natural sciences confront similar limitations. In order to work, the machines which engineers produce must also operate in controlled conditions. Collins says that nearly every success of the natural sciences was achieved thanks to the construction of closed systems. Take the automobile engine for example. The automobile engine is a closed physical space within which selected factors are allowed to operate: several basic rules of mechanics, electricity and chemistry work in predictable ways because the equipment has walls which shut out all other process. The machine usually breaks down because something external has interfered with the system's functioning (Collins 1992: 190; Latour 1983: 155).

The Role of Environmental Transformation: The Infrastructure of Everyday Life

In other words, machines usually need casing and/or modification of the environment in which they are to operate. This apparently applies to social machines too. Once again, both the socio-cultural context and the physical context need to be modified. The aforementioned encounter groups are obvious examples. In addition to micro-group effects and staff supervision of ongoing interactions, their basic condition of operation is isolation from the social context. This isolation is usually ensured by the physical infrastructure—separate rooms with appropriate proxemics (Hall 1996) or entire isolated therapy centres. It is worth considering how important the infrastructure of the companies they are modernizing is for the efforts of organization specialists. In particular, how important are the following factors: 1) isolation from other areas of practice; 2) various daily rituals which help employees to assume their prescribed roles; 3) the arrangement of office space which forces people to interact in particular ways and which also reflects the firm's organizational structure; 4) technologically advanced methods of work supervision which enable organizational changes and their effects to be registered. We must not forget, however, that enterprises are just one typical form of modern institution and as such they are highly rational systems where changes can be enforced quite efficiently and their effects can be monitored. It seems, therefore, that the functioning of social machines depends on sustainment of certain boundary conditions, the "infrastructure of everyday life." Such operations are of course yet another example of the transfer of patterns and blueprints developed in the laboratory to the outside world. The infrastructure of everyday life can include modifications in the domain of proxemic relations, especially in such areas as technology, architecture or other elements of material culture. Here we find the crucial advantage of chemistry, physics and other natural science disciplines: networks in which their products can function smoothly have been successively constructed for centuries. New technological layers have been built on older ones and the achievements of predecessors have been taken advantage of. In many cases the networks in which socio- or psycho-techniques could function would have to be built almost from scratch.

One good example of socio-technical modification of environment is practical environmental psychology. Let us name, for example, the social engineering ideas developed by Paco Underhill, the founding presidentof Envirosell.[5] On the assumption that the environment has an effect on our behaviour, Underhill decided to study the effects of spatial organization of shopping malls on consumer behaviour. He applied the participant observation method in various types of shops. He also used video cameras to register customer behaviour. The data he collected allowed him not only to identify general patterns of consumer behaviour but above all to meticulously structure shopping space (e.g. to plan how to place goods on shelves and hangers or in shopping windows) in order to maximize profit. Although Underhill tried to generalize his observations, it is usually necessary to conduct painstaking analysis of each particular shop and to tinker with the different elements in order to apply his findings in practice. In other words, although Underhill did not formulate any general rules of social influence, he provided a paradigmatic example of how to adjust the space of a particular shop so that it becomes a relatively efficient profit maximizing machine (Underhill 2000).[6]

---

5 Cf. http://www.envirosell.com

6 We must not forget, however, that environmental psychologists also apply similar tactics to urban spaces (parks, promenades, benches, or streets), public facilities or other elements of our environment. Suffice it to mention, in particular, William H. Whyte (1968, 1980, 1988) and his *Street Life Project*. Not only does Whyte present detailed analyses of urban space, he also suggests ways of modifying it (Whyte took an active part in e.g. the revitalization of Bryant Park in New York).

The role of physical infrastructure and its components is extremely important from the point of view of the construction of social machines. Social machines consist not only of purely social or cultural elements, as their name may suggest. According to actor-network theory (ANT, Callon 1991; Latour 1999), social relations are consolidated by means of technological and material factors to which social norms and functions are delegated. For example, speed bump (aka 'sleeping policeman') embodies norms regulating speed limits and heavy key rings which are attached to hotel keys are meant to prevent absentminded guests from taking their keys with them when they leave the building. As Edward Hall demonstrated, the way space is arranged also enforces specific behaviours and social activities and inhibits others. From the ANT perspective, such institutions as firms consist not only of staff, rules and norms but also of various physical elements. Let us mention, for example, such factors as the aforementioned proxemic factors or technological surveillance (security control gates or CCTV to which social control is delegated) but also modern IT (computers, information networks, telephones etc.) and various traditional; analogue office media;(sheets of paper, information boards, catalogues, forms, letters etc.) which enable communication, collective problem solving, cooperation and action coordination (Kirsh 2001).[7]

In order to draw attention to the technological components of social relations and processes, one of the authors of ANT, the aforementioned Bruno Latour, introduced the category of hybrid (Latour 1993). Hybrids are combinations of the material and the technological, the discursive and the cultural. He also writes about socio-technical systems in this context (Latour 1999). Of course not only spontaneous and traditional social relations have a hybrid nature. So do the products of social engineering. The ANT approach therefore suggests that in order to develop effective socio-technics, one must focus to an equal extent on people and human relations, and on the environment itself. Effective socio-technics involve not only culture in the narrow sense but also socio-technical structures (cf. also Berg 1998; Bowker, Star, Turner, & Gasser, 1997). And here lies the difference between social engineering/sociotechnics as manipulating people and the construction of social machines.

Meanwhile, sociotechnics are marginal in mainstream sociology and if they are mentioned at all, they are mentioned as a specific type of manipulative techniques. In order to reconstruct sociologists' approach to sociotechnics and social engineering, we analyzed the contents of mainstream social science journals (*Social Problems*, *Social Networks*, *American Sociological Review*, *British Journal of Sociology*, *American Journal of Sociology*, *Sociological Methodology*, *Annual Review of Sociology*, *International Sociology*, and *Sociological Inquiry*). We analyzed the abstracts, titles and (in many cases) conclusions of scientific articles published in these journals in 1998–2007. We came to the following conclusions:

1. If sociotechnics is mentioned at all, it is understood as a form of speculative application of knowledge;

[7] Cf. the "Context Aware Office" cognitive ethnography project realized with the Interactive Cognition Lab (UCLA) (Kirsh 2001; http://adrenaline.ucsd.edu/external/projects/contAware/ethnoStudies/html).

2. Standard conceptualizations of sociotechnics and social engineering ignore the role of infrastructure development and management of the context within which social interactions take place;
3. They also ignore the role which non-social factors such as various artefacts or technologies play in the interactions and processes which social scientists analyze.

Let us return to the problem of environmental transformation, however. Shaping the material context of operation of social systems is just as important as intervening in interpersonal relations or in the symbolic-axiological plane. Let us analyze the New York subway, for example.[8] In the 1980s the New York City Department of Transportation decided to test the broken windows theory, originally formulated by James Q. Wilson and George Kelling (1982). According to this theory, to a certain extent crime is the consequence of disorder, lack of monitoring and social control. This can be illustrated by the broken window effect. If a broken window, be it a shop window or other window, is not replaced quickly this is interpreted as permission to behave illegally. It is a clear signal that nobody is in charge of the house or shop. It can also be read as a signal that previously existing norms and sanctions have been suspended. People therefore feel free to behave in analogous ways and also to commit other crimes such as mugging, assault or robbery.

The goal in New York was to put a stop to the wave of crime which had overcome the whole city and especially the subway. In the latter case graffiti were the analogue for the broken windows. Many decision makers felt that to focus on drawings on the wall in order to control crime was, metaphorically speaking, like scrubbing the deck of the Titanic before it hit the iceberg. David Gunn, the project manager, decided nevertheless that the key to victory in the war on crime did indeed lie in conquering the graffiti plague. It takes a few days to complete graffiti. First you prepare the surface and put on a coat of ground paint, then you draw the contours, and finally you draw whatever you mean to draw. The metro personnel therefore had time to locate the wagons on which new graffiti were to be painted. They kept these wagons in the depot. Graffiti which had taken three nights to complete were removed immediately (often observed by the authors) before travellers could set eyes on them. This was a clear signal that no wagon devastation was going to be tolerated. The war on graffiti lasted from 1984 to 1990.

The next step in the war on crime was managed by William Bratton, the subway boss. Bratton focused his attention on fare dodgers and gate crashers. Fare dodging had become another symptom of the general slacking of social norms. Special plain clothes police units were delegated to catch the culprits. Those who were caught were handcuffed and presented to the public on the platforms. The system of transportation to the police station was streamlined. People began to pay their fares and offenders began to leave their guns at home for fear of being caught at check points. Crime in the New York subway—both fare dodging and vandalism—gradually began to subside. The number of more severe crimes also dropped immensely. The victory in the war on crime in the New York subway was so spectacular that in 1994 Bratton was nominated

[8] Cf. Gladwell 2003: 135–151.

NYC chief inspector and was now to apply the methods positively verified in the metro in the whole city.

The New York City subway system, with the changes proposed by Kelling, Gunn and Bratton, can be viewed to a certain extent as a social machine or at least a "social change laboratory." The three actors did indeed tinker with the metro infrastructure. They also modified the behaviour of other actors in a way that brought about stable social effects. They were able to do so both because the metro staff practiced uninterrupted surveillance and intervention but also because the underground railway is a specific space. It is a closed and relatively small environment (compared at least with entire districts) and was largely under their control. Many interventions and improvements could therefore be introduced. The applied means of surveillance were a source of essential data which could then be used to assess the process of metro modernization.

Two Case Studies: Chiat/Day vs. Gore & Associates

Let us begin with a rather trivial observation: if we want to achieve our desired engineering effects not only must we shape the environment but we must also do this skilfully. Solutions which seem to be feasible enough theoretically often turn out to be unpractical or even counterproductive. We also have to deal with the problem of how to transfer favourable socio-technical solutions to new social contexts. We would now like to demonstrate the difference between an efficient and functional social machine and a social machine which proved to be a failure. We shall use two examples: W. L. Gore & Associates and Chiat/Day. We shall also take this opportunity to demonstrate the role of technological, material and proxemic factors in the functioning and engineering of social organizations.

Case 1: Gore & Associates (based on Gladwell 2003: 182–192)

W. L. Gore & Associates[9] specialize, among other things, in the production of membranes inserted into footwear and jackets. These membranes are familiar all over the world. The firm was the target of a very interesting social engineering solution. The organization of the firm is based on the assumption that its different units will work most effectively in an intimate climate which will enable direct contact between employees, a milieu typical for small social groups. Therefore, the traditional pyramid organizational structure was discarded. The company was divided into many separate and largely autonomous branches. Each branch employed about 100–150 people who mainly interacted with one another. In such a small group it is possible to maintain the processes which are typical of traditional communities. Employees within each branch know each other personally and interact informally and directly, i.e. face-to-face. This interaction mode encourages innovation, good information flow and very rapid decision execution. The branches are based on first degree social control

[9] Cf. www.gore.com

(Podgórecki 1979). This model is in direct opposition to the bureaucratic models which have been thought to be the most effective management models at least since the days of Max Weber.

The work organization model applied by W. L. Gore & Associates was achieved through a quite simple operation: each branch's buildings were designed in such a way that they could not house more employees than the aforementioned limit. They were also designed in such a way that employees were forced to interact frequently so as to facilitate integration (Gladwell 2003: 182–192). Despite its systematic expansion, the company continued to adopt this policy and to divide its branches into smaller units so as to maintain the desired effect. This way, company managers delegated (cf. Latour 1991, 1992) some of their functions to the building infrastructure and proxemics (Hall 1966). This is an excellent example of the role which the infrastructure of everyday life plays in the engineering of social processes. This modelling approach has led to the development of a relatively autonomous social machine. Hopefully, by introducing employees to such an environment, we shall soon encourage the desired type of interactions and work organization with minimal supervisory interference. In other words, social engineering, via the infrastructure of everyday life, is able to encourage *Lebenswelt*, at least to a certain extent.

Case 2: Chiat/Day (based on Brown & Duguid 2003: 70–75)

Chiat/Day undertook an analogous attempt to engineer social relations by modifying the proxemics and architecture of its offices. This was a well-known Los Angeles advertising agency.[10] It owes its fame to its many commissions for Apple, including Apples advertising spot projected during Superbowl in 1984 and its *Think Different* campaign. The key to the firms continued competitive power was to be the architectural project for its building designed by Frank Gehry and realized in 1985–1991. The basic assumption underlying the layout was that nobody should have a place of their own. Instead, on entering the building every employee was to collect a laptop and mobile telephone and find a seat in the enormous common room (only the conference rooms were traditionally designed). Managers were to cruise the room continually and make sure that workers were mingling. They split any pairs who occupied the same seats on two days in succession. All work was to be done on laptops, without paper. All equipment was to be handed in at the end of the day on exiting the building. Theoretically, employees were to enter numerous creative relations with representatives of all sorts of specialities. Within five years the company was on the brink of bankruptcy. The new owner chucked the previous organization and the spatial office layout. He returned to more traditional solutions. Several questions come to mind at this point: Why did a solution which seemed so obvious to so many people prove to be an organizational fiasco?

First, it ignored the way people use office space, forms, printouts and other elements of office equipment. Everybody tends to arrange his or her surroundings in a way

[10] Chia/Day and TBAWA WorldWide merged in 1993. Chiat/Day operates in California to this day. It is known as TBWA/Chiat/Day. Cf www.tbwachiat.com

which will allow him/her to work (Kirsh 1995). We delegate functions relating to effective work to our environment. Meanwhile, at Chiat/Day employees had to reconstruct their work environment almost from scratch every day. No wonder, therefore, that they soon began to protest and openly boycott the superimposed solutions (they smuggled laptops home, collected forbidden printed materials and notepaper, booked desks).

Second, it ignored the functions played by spatial segregation of employees according to speciality. When a worker has a problem he or she cannot solve, he/she simply turns to colleagues at the next desk who are working on similar problems. This applies equally well to company strategy, specific commissions, or simple problems with office appliances. A well-designed office is able to produce a strong environment conducive to situated learning (Lave & Wegner 1993) and tacit learning. At Chiat/Day this type of collective activity was impossible because representatives of a given speciality were scattered all over the place.

The most serious mistake, however, was that on the one hand the organizers wanted to develop a collective work model but on the other hand they retained existing organizational structures—traditional departments and specialities were not liquidated. The spatial arrangements made close cooperation within work groups and units impossible. At the same time, however, department managers began to send their subordinates to reserve specific desks early in the morning. Representatives of other specialities were thrown out of more comfortable locations, senior employees threw out junior employees etc. Instead of a stable structure there were endless time and attention consuming negotiations and quibbles.

To summarise, Chiat/Day tried to engineer a university campus atmosphere in its building, a "melting pot of ideas." Students do not have desks of their own—it reasoned. They wander from lecture hall to lecture hall, library or club. All the company actually succeeded in doing, however, was to evoke an American high school atmosphere with its typical bullying. Innovation was a fiasco because the stable relations typical of office work were ignored, as were socially embedded patterns of behaviour and problem solving (also evident in specific office and desk layouts). The masterminds overlooked the role of such mundane artefacts as sheets of paper. Most importantly, however, they tried to implement an abstract vision of social relations but failed to adjust it to the specific conditions or to monitor the actual outcomes of their new approach.

Conclusions

It is worth mentioning that, in addition to the ones mentioned above, there are many other examples of socio-technical projects in social reality. These projects involve utilising the properties of the material environment, proxemics and the new media (cf. e.g. Beunza & Stark 2003, 2004, 2005; Brown & Duguid 2003: 100–112; Hutchins 1995). However, not all these innovations are the effect of intervention by professional social researchers, e.g. researchers in organization theory (Scott 1992). Many of these projects are the ideas of specialists in the cognitive sciences, ergonomics, human factors or human-computer interaction. Most of them, however, seem to be the effect of spontaneous, grass-roots innovations and years of institutional evolution. The best example if this type of innovation is perhaps the keiretsu organization, an outgrowth of Japanese culture (Castells 2001: 190–191) and a related form of management called Toyotism (Castells 2001: 169–172). Organizational solutions such as these not only help to reduce costs (the just-in-time strategy) but also to maintain a high level of creativity. Most importantly, they are extremely flexible. Just how well they are able to adapt to crisis situations is evidenced by the Toyota—Aisin Seikai crisis induced when one of the key factories in the Toyota production network burned down.[11]

Having analyzed these case studies and other similar organizational innovations we can now draw some engineering conclusions. Systematic advancement of synthetic methodology in the social sciences should assume the need to capitalize on such practical knowledge, to test it and to try to reproduce model machines in various socio-cultural contexts. We must remember, however, that the transfer of technology (including social technology) to new contexts is not a trivial matter. We cannot do it automatically. More often than not, we must adjust it to specific circumstances.

To wind up our narrative we must make one more fundamental reservation: the purpose of synthetic methodology is not just to engineer the social fabric, it is also to gain a deep understanding of it. Engineering practice is organically connected to cognitive practice. As anthropology of science has taught us, prediction and innovation are two aspects of one and the same process. They have the same structure and assume analogous techniques and methods. In this article we have adopted an epistemology based on intervention in the object of study. Doubtless to say, there are very few social systems which can be reproduced in traditional laboratories. Perhaps one possible solution would be to try to view the world as a social science laboratory. We wish to emphasize that we are talking about deliberate and systematic experimenting with concrete social relations and structures. Such (methodologically and socially) uncontrolled experiments on the social fabric have been conducted for a long time. We are talking not only about interventions by organization specialists but also about interventions by natural scientists who, by implementing their innovations, are in fact changing society profoundly.

Final Conclusions: The Social Machine Metaphor and Its Limitations

We have focused in this article on the analysis of patterns of selected disciplines of natural science. Taking anthropology of science as our point of departure we have tried to explain how certain areas of the social sciences could function (and

[11] On 1 February 1997 the entire Toyota keiretsu stopped producing motorcars when its Aisin Seiki factory was destroyed in a fire. Aisin Seiki was the sole producer of the brake valves which were used in all Toyota cars. It would have taken many months to rebuild the factory. However, thanks to the network organizational structure, Toyota workers and engineers managed to renew production within just a week by tinkering with existing production lines. They succeeded even though production of the valves required specialist equipment and high-precision execution (Watts 2003: 254–260).

sometimes even do function). We have concentrated on both artificial social systems and the need to transform the contexts in which these systems operate. In a way, we have suggested turning the existing order upside down. Instead of assuming that social engineering is the point of arrival of the social sciences, we have postulated that it may be the point of departure. Within the present text, social engineering is understood not as an application of abstract knowledge (this seems to be the dominant understanding of social engineering and sociotechnics associated with social influence or ideological activities, cf. Podgórecki 1972; Podgórecki, Alexander & Shields, 1996) but as tinkering and modifying the social fabric and as a form of cognitive experimentation (Afeltowicz & Pietrowicz, 2008a).

Finally we would like to approach the problem of social machines from a slightly different vista. So far, we have been using this concept as a heuristic metaphor, a sensitizing concept according to Herbert Blumer (1954). Concepts are not innocent, however. Like every metaphor, the "social machine" has its advantages and disadvantages. The advantages of using this particular concept are as follows.

1. The metaphor adopted in this article highlights the fact that there are no easy applications in the social sciences (or in the natural sciences either).
2. Social sciences' technological applications cannot be reduced to the application of knowledge and recommendation giving; they should involve constructing a closed, reproducible system by means of pragmatic tinkering and experimenting.
3. If machines are to function, the environment must be reconfigured—an adequate infrastructure of everyday life must be developed and the isolation effect must be guaranteed.
4. Implementation of social innovations cannot be limited to the modification of the symbolic sphere or to purely social practices and relations. It must involve the transformation of material culture—technology and infrastructure. The role of the latter in the functioning of social systems has been argued by ANT.
5. If social machines are to function smoothly, personnel interventions are also necessary, just as they are in natural science products.
6. The metaphor of social machine construction suggests that sociologists ought to adopt a pragmatic epistemological stance. Sociology should become a form of social tinkering, at least partly. Researchers should experiment with real social systems and their infrastructure. But they should not try to design ready-made social relation systems. Instead of applying theory, they should introduce pragmatic corrections and try to create reproducible mechanisms.

This metaphor can also be misleading.

1. Many people may associate this metaphor with a "ruthless social machine" or the "cogwheels of totalitarian system." This is certainly what happens in the case of many of the "inventions" of modern rationalized society—military institutions, bureaucratic structures, very hierarchical enterprises, mental hospitals (but not only mental ones), prisons, boarding schools etc. (Goffman 1961). However, many contemporary social machines are as far removed from these patterns as possible. Suffice it to mention encounter groups, companies such as Gore & Associates or

spaces designed by environmental psychologists. These are not social machines which are like refrigerators whose goal is to enforce or "freeze" the practices, relations and behaviours of social actors within certain configurations. Rather, they are subtle interventions and operations whose goal is to generate appropriate boundary conditions and isolate interfering factors.

2. The fact that we are dealing with machines does not mean that we can build them into every social context. As we know, STS questioned the vision of the universal applicability of the products of the natural sciences. Analogously, we cannot simply transfer social machines into new surroundings and expect them to function smoothly. This does not mean, however, that such transfer is impossible because of cultural factors. Once again we need to resort to engineering tinkering—we must adjust our innovations to specific, concrete contexts.

References

Abriszewski, Krzystof; Afeltowicz, Łukasz. 2007. "Jak gołym okiem zobaczyć neurony i siłę alergii? Krążąca referencja w nauce i poza nią," *Zagadnienia Naukoznawstwa*, no 3–4 (173–174), Vol. XLIII: 405–420.

Afeltowicz, Łukasz; Pietrowicz, Krzysztof. 2008a. "Maszyny społeczne. Inżynieria społeczna w nowej perspektywie," *Kultura i Edukacja*, no 2: 7–25.

Afeltowicz, Łukasz; Pietrowicz, Krzysztof. 2008b. "Koniec socjologii jaką znamy, czyli o maszynach społecznych i inżynierii socjologicznej," *Studia Socjologiczne*, no 3 (190): 43–73.

Afeltowicz, Łukasz; Pietrowicz, Krzysztof. 2009. "Czy socjologowie są w stanie budować maszyny społeczne? Rekonceptualizacja różnicy między przyrodoznawstwem a naukami społecznymi," *Kultura i Społeczeństwo*, no 1 (53): 17–45.

Baird, Davis. 2004. *Thing Knowledge. A Philosophy of Scientific Instruments*. Berkeley, Los Angeles, London: University of California Press.

Berg, Marc. 1998. "The Politics of Technology: On Bringing Social Theory into Technological Design," *Science, Technology & Human Values*, 4: 456–490.

Beunza, Daniel; Stark, David. 2003. "The organization of responsiveness: innovation and recovery in a trading rooms of Lower Manhattan," *Socio-Economic Review*, 1: 135–164.

Beunza, Daniel; Stark, David. 2004. "Survival and Sensemaking: Organizational Resilience in a Wall Street Trading Room After 9/11," Universitat Pompeu Fabra Economics and Business Working Paper No. 734.

Beunza, Daniel; Stark, David. 2005. "How to Recognize Opportunities: Heterarchical Search in a Trading Room," in: K. Knorr-Cetina, A. Preda (ed.), *The Sociology of Finacial Markets*. Oxford: Oxford University Press.

Bijker, Wiebe E. 1995. *Of Bicycles, Bakelites, and Bulbs. Toward a Theory of Sociotechnical Change*. Cambridge, Mass.: MIT Press.

Bijker, Wiebe E. 1997. "The Social Construction of Bakelite: Toward a Theory of Invention," in: W. Bijker, T. Hughes, T. Pinch (eds.), *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology*. Cambridge, Mass.: The MIT Press, 159–187.

Bijker, Wiebe; Law, John (eds.). 1992. *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, Mass.: The MIT Press.

Bijker, Wiebe E.; Hughes, Thomas P.; Pinch, Trevor J. (eds.). 1997. *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology*. Cambridge, Mass.: The MIT Press.

Billari, Francesco C.; Fent, Thomas; Prskawetz, Alexia; Scheffran, Jurgen (eds.). 2006. *Agent Based Computational Modelling: Applications in Demography, Social, Economic and Environmental Sciences*. Heidelberg: Physica-Verlag.

Blumer, Herbert. 1954. "What is Wrong with Social Theory?," *American Sociological Review*, 1: 3–10.

Bowker, Geoffrey C.; Star, Susan Leigh; Turner, Wiliam; Gasser, Les (eds.). 1997. *Social Science, Technical Systems and Cooperative Work. Beyond the Great Divide*. Mahwah, New Yersey: Lawrence Erlbaum Associates.

Brown, John Seely; Duguid, Paul. 2000. *The Social Life of Information*. Boston: Harvard Business School Press.

Callon, Michel. 1991. "Techno-economic Networks and Irreversibility," in: J. Law (ed.), *A Sociology of Monsters: Essays on Power Technology and Domination*. London: Routledge, pp. 132–161.

Carnap, Rudolf. 1995. *An Introduction to the Philosophy of Science*, edited by Martin Gardner. Mineola, NY: Courier Dover Publications.

Cartwright, Nancy. 1999. *The Dappled World. A Study of the Boundaries of Science*. Cambridge: Cambridge University Press.

Castells, Manuel. 2000. *End of Millenium*. Second Edition. Oxford, Malden, MA: Blackwell Publishers.

Castells, Manuel. 2001. *The Rise of the Network Society*. Second Edition. Oxford, Malden, MA: Blackwell Publishers.

Cole, Stephen. 1994a. "Introduction: What's Wrong with Sociology?," *Sociological Forum*, 2, Special Issue: *What's Wrong with Sociology?*: 129–131.

Cole, Stephen. 1994b. "Why Sociology Doesn't Make Progress like the Natural Sciences," *Sociological Forum*, 2, Special Issue: *What's Wrong with Sociology?*: 133–154.

Collins, Harry M. 1974. "The TEA Set: Tacit Knowledge and Scientific Networks," *Social Studies of Science*, 4: 165–86.

Collins, Randall. 1992. "The Confusion of the Modes of Sociolog," in: S. Seidman, D. G. Wagner (eds.), *Postmodernism and Social Theory: The Debate over General Theory*. Cambridge, Mass.: Blackwell, pp. 82–92.

Collins, Randall. 1994. "Why the Social Science Won't Become High-Consensus, Rapid Discovery Science," *Sociological Forum*, 2, Special Issue: *What's Wrong with Sociology?*: 155–177.

Collins, Randall. 1998. *The Sociology of Philosophies: A Global Theory of Intellectual Change*. Cambridge, Massachusetts: Belknap Press.

Davis, James A. 1994. "What's Wrong with Sociology?," *Sociological Forum*, 2, Special Issue: *What's Wrong with Sociology?*: 179–197.

Epstein, Joshua M. (eds.). 2005. *Generative Social Science. Studies in Agent-Based Computational Modeling*. Princeton: Princeton University Press.

Epstein, Joshua M.; Axtell, Robert. 1996. *Growing Artificial Societies. Social Science from the Bottom Up*. Washington, Cambridge, Mass.: Brookings Institution Press/MIT Press.

Fuchs, Stephan. 1992. *The Professional Quest for Truth: A Social Theory of Science and Knowledge*. Albany: SUNY Press.

Fuchs, Stephan. 1993. "Three Sociological Epistemologies," *Sociological Perspectives*, no 1: 23–44.

Gilbert, Nigel. 2004. *Agent-based social simulation: dealing with complexity*. http://cress.soc.surrey.ac.uk/resources/ABSS%20-%20dealing%20with%20complexity-1-1.pdf [24.04.2008].

Gladwell, Malcolm. 2003. *The Tipping Point. How Little Things Can Make a Big Difference*. London: Abacus.

Goffman, Erving. 1961. *Asylums: essays on the social situation of mental patients and others inmates*. Garden City, NY.: Doubleday & Company, Inc.

Gooding, David. 2004. "Seeing the Forest for the Trees: Visualization, Cognition, and Scientific Inference," in: Michael Gorman, Ryan Tweney, David Gooding, Alexandra Kincanonn, *Scientific and Technological Thinking*, Mahwah, New Jersey: Lawrence Erlbaum: 173–217.

Hacking, Ian. 1983. *Representing and Intervening. Introductory Topics in the Philosophy of Natural Science*. New York: Cambridge University Press.

Hacking, Ian. 1999. *The Social Construction of What?* Cambridge, Mass.: Harvard University Press.

Hawking, Stephen. 2001. *The Universe in a Nutshell*. New York: Bantam Books.

Hall, Edward T. 1966. *The Hidden Dimension*. Garden City, New York: Doubleday.

Hutchins, Edwin. 1995. *Cognition in the Wild*. Cambridge, Mass.: The MIT Press.

Kirsh, David. 1995. "The Intelligent Use of Space," *Artificial Intelligence*, no 1–2, Vol. 73: 31–68.

Kirsh, David. 2001. "The Context of Work," *Human Computer Interaction*, 2: 305–322; on: http://interactivity.ucsd.edu/articles/HCI/final.html

Knorr-Cetina, Karin. 1981. *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon Press.

Knorr-Cetina, Karin. 1999. *Epistemic Cultures. How the Sciences Make Knowledge*. Cambridge, Mass.: Harvard University Press.

Knorr-Cetina, Karin, Mulkay, Michael (red.). 1983. *Science Observed: Perspectives on the Social Study of Science*. London: SAGE Publications.

Lave, Jean, Wenger, Etienne. 1993. *Situated Learning: Legitimate Peripheral Participation*. New York: Cambridge University Press.

Latour, Bruno. 1983. "Give Me a Laboratory and I will Raise the World," in: Karin Knorr-Cetina, Michael Mulkay (eds.), *Science Observed: Perspectives on the Social Study of Science*. London: SAGE Publications, pp. 141–70.

Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge, Mass.: Harvard University Press.

Latour, Bruno. 1988. "Drawing Thing Together," in: Michael Lynch, Steve Woolgar (eds.), *Representation in Scientific Practice*. Cambridge, Mass.: The MIT Press, pp. 19–68.

Latour, Bruno. 1991. "Technology Is Society Made Durabl," in: John Law (eds.), *A Sociology of Monsters: Essays on Power, Technology and Domination*. London, New York: Routlege, pp. 103–131.

Latour, Bruno. 1992. "Where Are the Missing Masses? Sociology of a Few Mundane Artefacts," in: W. Bijker i J. Law (eds.), *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, Mass: MIT Press, pp. 225–258.

Latour, Bruno. 1993. *We Have Never Been Modern*. New York: Harvester Weatsheaf.

Latour, Bruno. 1999. *Pandora's Hope: Pandora's Hope: Essays on the Reality of Science Studies*. Cambridge, Mass.: Harvard University Press.

Latour, Bruno. 2000. "When Things Strike Back: A Possible Contribution of 'Science Studies' to the Social Sciences," *British Journal of Sociology*, 1: 107–123.

Latour, Bruno. 2004. *Politics of Nature. How to Bring the Sciences into Democracy*. Cambridge, Mass: Harvard University Press.

Latour, Bruno, Woolgar, Steve. 1979. *Laboratory Life: The Social Construction of Scientific Facts*. SAGE Library of Social Research. Beverly Hills: SAGE Publications.

Levi-Strauss, Claude. 1966. *The Savage Mind*, translated by John Weightman, Doreen Weightman. Chicago: University of Chicago Press.

MacKenzie, Donald. 1997. "Missile Accuracy: A Case Study in the Social Processes of Technological Change," in: W. Bijker, T. Hughes, T. Pinch (eds.), *The Social Construction of Technological Systems. New directions in the Sociology and History of Technology*. Cambridge, Mass.: The MIT Press, pp. 195–222.

MacKenzie, Donald. 1998. *Knowing Machines. Essays on Technical Change*. Cambridge, Mass.: The MIT Press.

Merton, Robert K. 1948. "The Self-fulfilling Prophecy," *The Antioch Review*, 8: 193–210.

Merton, Robert K. 1968. *Social Theory and Social Structure*. New York: TheFree Press.

Mokrzycki, Edmund. 1980. *Filozofia nauki a socjologia. Od doktryny metodologicznej do praktyki badawczej* [Philosophy of Science and Sociology. From the Methodological Doctrine to Research Practice]. Warszawa: PWN.

Nowak, Stefan. 2006. *Metodologia nauk społecznych* [Methodology of the Social Sciences]. Warszawa: PWN.

O'Connell, Joseph. 1993. "Metrology: Creation of Universality by the Circulation of Particulars," *Social Studies of Science*, 1: 129–73.

Ossowski, Stanisław. 1967. "O osobliwościach nauk społecznych" [On the Peculiarities of the Social Sciences], in: S. Ossowski, *O nauce* [On Science]. Warszawa: PWN.

Pfeifer, Rolf; Bongard, Josh. 2007. *How the Body Shapes the Way We Think. A New View of Intelligence*. Cambridge, Mass.: MIT Press.

Pickering, Andrew (red.). 1992. *Science as Practice and Culture*. Chicago, London: The University of Chicago Press.

Popper, Karl R. 1965. "Unity of Method in the Natural and Social Sciences," in: D. Braybrooke (eds.), *Philosophical Problems of the Social Sciences*. New York: MacMillan Co., pp. 32–41.

Popper, Karl R. 1959. *The Logic of Scientific Discovery*. London: Routledge.

Podgorecki, Adam. 1979. "Tertiary social control," in: Adam Podgorecki, Maria Łoś, *Multidimensional Sociology*. London: Routledge.

Podgorecki, Adam; Alexander, Jon; Shields, Rob (eds.). 1996. *Social Engineering. The Technics of Change*. Ottawa: Carleton University Press.

Scott, W. Richard. 1992. *Organizations: Rational, Natural, and Open Systems*. Englewood Cliffs: Prentice-Hall International.

Sojak, Radosław. 2004. *Paradoks antropologiczny. Socjologia wiedzy jako perspektywa ogólnej teorii społeczeństwa* [Anthropological Paradox. Sociology of Science as a Perspective of General Theory of Society]. Wrocław: Wydawnictwo Uniwersytetu Wrocławskiego.

Sneed, Joseph Donald. 1979. *The Logical Structure of Mathematical Physics*. Dordrecht, London: D. Reidel.

Stinchcombe, Arthur S. 1994. "Disintegrated Disciplines and the Future of Sociology," *Sociological Forum*, 2, Special Issue: *What's Wrong with Sociology?*: 279–291.

Underhill, Paco. 2000. *Why We Buy: The Science Of Shopping*. New York: Simon & Schuster.

Watts, Duncan J. 2003. *Six Degrees. The Science of a Connected Age*. New York, London: W. W. Norton & Company.

Watts, Duncan J.; Dodds, Peter Sheridan. 2007. "Influentials, Networks, and Public Opinion Formation," *Journal of Consumer Research*, 34: 441–458.

Wilson, James Q.; Kelling, George L. 1982. "Broken Windows: The Police and Neighborhood Safety," *The Atlantic Monthly*, March: 29–38.

Whyte, William H. 1968. *The Last Landscape*. Garden City: Doubleday.

Whyte, William H. 1980. *The Social Life of Small Urban Spaces*. New York: Project for Public Spaces.

Whyte, William H. 1988. *City: Rediscovering the Center*. New York: Doubleday.

Zybertowicz, Andrzej. 1995. *Przemoc i poznanie. Studium z nie-klasycznej socjologii wiedzy* [Force & Recognition. Study from Non-Classic Sociology of Science]. Toruń: Wydawnictwo UMK.

Zybertowicz, Andrzej. 1999. "The Success of the Natural Sciences Sociologically Explained," *Studia Metodologiczne*, 29: 11–34.

Biographical Notes: Krzysztof Pietrowicz received his Ph.D. in Sociology from Nicolaus Copernicus University in 2005. He is currently deputy director and assistant professor at the Institute of Sociology, NCU, Toruń. His scholarly interests have concentrated over the last four years on social engineering and practical sociology, as well as on social network analysis (SNA), science and technology studies (STS) and methodology of social sciences. Since April 2010 he is the head of the research project funded by Polish Ministry of Science and Higher Education, "Contemporary social engineering. Innovations in social sciences and natural sciences" (N N116 294938).

E-mail: krzysztof.pietrowicz@umk.pl

Łukasz Afeltowicz received his Ph.D. in Philosophy from Nicolaus Copernicus University in 2010. His research interests include actor-network theory (ANT), science and technology studies (STS), and cognitive studies of science and technology. In previous research, he has focused on social aspects of thermonuclear fusion research. Current research projects include studies on diversity of research styles in natural and social sciences, and sociological analysis of biological epidemics and medicalization.

E-mail: afeltovicz@gmail.com