Ingemar Nordin

The rationality of technology

The theory of technology put forth in this article[1] aims at answering a few general questions that may be asked about technical development. What is the logic of technological research? What is its dependence on external factors in society? Is it rational, given its goal to produce useful techniques?

After a few preliminary remarks concerning the distinction between such concepts as theory and technique, truth and usefulness, and science and technology, I will suggest a definition of usefulness suitable as a goal for a rational technology. Next, four main models of technology will be presented. One of them, the paraprax, is argued to be the most realistic. The last task will be to state the conditions for a rational technology, given the paraprax-model and the criteria drawn from our analysis of the concept of usefulness.

Truth and usefulnes

Let me state a few "facts" about techniques: techniques are what technology — seen as a research activity — produces. Machines are techniques. But so are many repetitive — and therefore machinelike — actions and processes (for this property of techniques, see also Mumford, 1961; Barret, 1978 and Kuhns, 1971 on S. Giedich). To cut timber or wash clothes according to a certain recipe is a technique. All techniques have intentions and are therefore artifacts. Contrary to other repetitive intentional acts such as dancing and playing, techniques are intended to solve practical problems. Technology is a creative process and it is therefore not a technique. This gives an indication of how the terms in question will be used henceforth.

If we compare techniques with theories (cf. Bunge, 1967; 1972), it is easy to discover several differences. For example, theories have truth-values while techniques do not. We may ask a person whether his car works or not, or if he has much use for it. But there is no point in asking him whether his car is true or not. Another difference is that while there may exist several competing techniques that are able to do practically the same thing, there can be no more than one true theory among many competing theories. It is impossible to travel from Sweden to Europe both by car and by air at the same time, but each method is practicable.

Evidently, the logic of values such as "works — does not work" and "usable — not usable" is quite different from the logic of truth-values. And the logic of truth-values is not applicable to techniques.

A good illustration of the distinction between "truth" and "usefulness" is the fact that many a good technique has been based on false theories. The breeding of animals, the production of metals from calx, the steam-engine and many useful medical cures were all once based on theories that we consider to be false today. Indeed, it is not uncommon, nor inappropriate, for the engineers of today to base their inventions on theories *knowing* that they are false. They are interested in usable theories, not necessarily in true ones.

How about scientific theories? Do all useful techniques have to be based on science? First of all, we should note that scientific theories are not automatically the same thing as true theories. If modern theory of science is correct then we have good reason to believe that most scientific theories are false. But are they necessary? To anwer that question we only have to ask ourselves whether there can be serviceable techniques that are based on non-scientific theories. And it is not very difficult to answer: yes, there is plenty of evidence that scientific theories are not a precondition for the usability of techniques. Some of the techniques mentioned before were based not only on false but also on non-scientific theories.

So, neither truth nor the scientific status of the knowledge involved is a necessary condition for producing useful techniques. Hence, considering the differences between truth and usefulness, there is good reason to believe that research aiming at usefulness should differ from research aiming at truth.

There is one more difference between truth and usefulness: truth is absolute. If it is true that 2+2=4, or that electrons are made of quarks, then this is true all over the world. It will also be true in the future as it has been in the past. And it makes no sense to claim that these propositions are only true for some individuals but not for others. On the other hand, usefulness is relative. For example, a bicycle seems to be quite useful in a town like Amsterdam but of little use in Los Angeles. The steam-engine was once of great value in Europe but is hardly usable today. And it often makes sense to claim that what is usable for one person is not necessarily usable for another. Evidently, the concept of usefulness has to be related to such things as time, place and individual persons.

A definition of usefulness

What does it take to be useful? We are dealing with techniques now; not theories, nor natural objects, nor people. In other words, we are dealing with criteria for the usefulness of machine-like objects or processes intended to solve practical problems. Let us start with the intentional character of techniques.

One single technique may of course be useful in many ways. (For example, a pen may be useful both for writing and for opening envelopes). When discussing the utility of techniques we have to be explicit about their various uses. What we are interested in here, considering the rationality of technology, is the use of a technique usually intended by its producer.

Each technique is intended to produce some kind of effect, A, when handled in a proper way. And it is quite obvious that this is one of the main concerns in technology: to make the technique T(A) work. Given that A is what we want, then the goal of the inventor is to come up with a technique that produces A in a reliable way. This task involves a logic of its own. Often we may choose between several approaches. Showing that one of them is successful does not prove that the others cannot be successful as well. But whichever approach is chosen, the technologist has to try out a repeatable and effective method for obtaining A.

I will mention two main problems involved in this process: 1) the technological problem of induction, and 2) the efficiency of T(A).

Technological induction is used to "prove" that an object works. For example, from the fact that I have successfully used the telephone beside me several times (and from my experience with telephones in general) I take it as proven that this phone works. And the problem, of course, is that there is not an ounce of validity to my belief.

Sometimes it is suggested that the validity of my belief comes from the fact that the technique is based on science. However, I do not believe that this is the case. First of all, science is not what makes *me* believe in the reliability of the telephone. If I were to buy a telephone, I would be much more interested in how the thing had worked so far than in whether it was constructed according to science or not. Secondly, the relation between science and technological reliability is rather the other way around: science has at long last proved its technological mettle by repeatedly showing its utility as a tool for constructing reliable techniques. Thirdly, science has its own problems of induction, showing that there is no valid method to prove by experience that a theory is true.

I have no solution to this problem. I merely wish to show the existence of a special, technological, problem of induction. Its existence arises from the fact that technology deals with actions based on beliefs. In science we actually do not have to trust anything. As scientists, we may forever remain critical, never betting our lives on any particular theory. However, in everyday life this is not so. Many beliefs have to be trusted, rational or not. Among those are the beliefs that most of the techniques surrounding us are working and will function in the way they are intended to. Certainly, we may increase our safety through monetary guarantees and insurances of various kinds. But both the institutions issuing guarantees and insurances and we, as individuals, still want to make as rational choices as possible[2]. Sometimes our very lives depend on choosing a reliable technique. On what do we ultimately base these choices, except on past experiences?

The special character of the technological problem of induction arises from the difference between truth and serviceability. To show that a theory "works" in the sense of being of value in constructing a technique does not, of course, show that it is true. False theories may work very well in this sense. A map may be strictly speaking false in small detail and still be of great help to us in finding our way through unknown terrain. Hence, showing the serviceability of a technique does not necessarily include the task of showing the truth of the belief on which the technique is based. Nor does it include the task of showing the non-serviceability of other competing techniques.

This brings us over to the efficiency of T(A). How efficient does T(A) have to be? Consider the map again. Obviously, the false map is not a hundred percent efficient since it may lead us wrong sometimes, especially if we are looking for some tiny detail misplaced on the map. Thus we may say that the efficiency needed is dependent on how we intend to use T(A).

Clearly, the efficiency needed is dependent on use, and use depends on the person and the situation in which he is. In other words, if T(A) does have a use, then it is working well enough. But what is the minimum condition for T(A) to be in working order? Could any degree of efficiency, even zero, count as sufficient, given a suitable user? For example, what if I were a person of infinite patience, prepared to settle for a phone that never got me on line? Would I still be using it?

The only reasonable answer here is "no". The serviceability needed must have some objective lower limit even if it is relative to the individual user. If a thing does not work at all, then it cannot be used as intended. I may even fool myself in believing that I use T(A) while actually not using it at all.

In order to define the concept of usefulness we need both objective and subjective criteria. The need for subjective criteria is justified by the fact that the usefulness of a technique depends on many factors concerning each user: goals, situations, knowledge and personality. The need for objective criteria is justified by the fact that we may misjudge the usefulness of a technique by overestimating its real efficiency.

I therefore suggest the following definition:

T(A) is useful if, and only if, a) there is at least one person x finding T(A) useful (in producing A), and b) T(A) does indeed produce A with an efficiency greater than zero and at least as high as percieved by x.

We may further note that techniques have to be known in order to be useful. Techniques that are now forgotten, or that are unknown for other reasons, simply cannot be useful.

This definition gives the minimal conditions for T(A) to be useful. Even if there is only one single person in the whole world (perhaps the inventor himself) who finds it useful, we cannot deny that it is usable. But we may certainly dispute its *degree* of usefulness.

There are two kinds of high degrees of utility. Either each user finds T(A) to be of great value, or there are many users of T(A). When discussing the rationality of technology later on, what we are interested in is of course the question of whether technology is able to optimize utility in either of these two senses. A technology giving rise to techniques with a high degree of utility is more rational than a technology that produces techniques with a low degree of utility.

The aim of rational technology then is to produce as useful techniques as possible. One has to invent a technique that produces the wanted effects in a way that is acceptable to the users. Furthermore, the efficiency of the techniques in question must be good enough.

Models of technology

Like science, technology may be influenced by both internal and external forces. Internal factors include technological level, science, objective criteria for choosing a suitable technique, and empirical evidence. External factors are everything external to the technological process, such as subjective wants of the user or the technologist, and social, economic and political interests in society at large.

The traditional view is that the tasks of technology, i.e. the practical problems that it tries to solve, are (or should be) given by external factors (c.f. Smookler, 1966; Rapp, 1981 among others). The whole point of technology is that it solves problems that we, as users, encounter in our everyday activities: at our domestic work, at our jobs, in industry, and so forth. However, given these external goals, the choice, or innovation, of a suitable technique is done by the expert. It is the technologist who has the competence to judge if, when or how a certain practical problem can be solved. Hence, the norms, or methods, of technology are internal. In short, the traditional model is that the goals of technology are externally given while its norms are internal.

With these two pairs of concepts, i.e. goals/norms and internal/external, we may easily construct three more models of technology. All four can be represented as in figure 1.

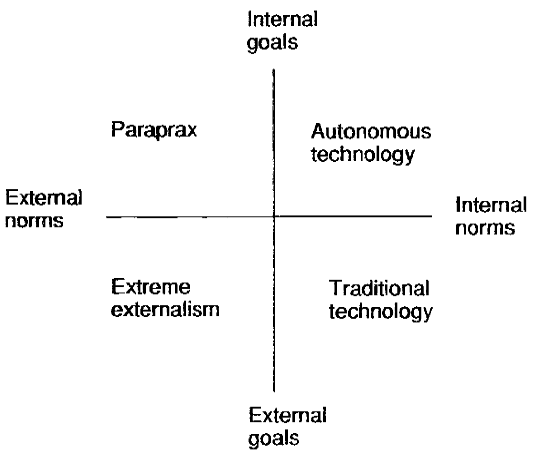

Figure 1. Four models of technology.

Let us sum up the pros and cons of these models. According to the traditional model, the technologist is like an English butler. Without betraying his own personal feelings he is always prepared to fulfill every wish of his master, no matter how irrational or whimsical they seem. It is simply not his business to make any judgements on his employer. He always understands what the master wants and he knows exactly what has to be done. However, he strongly disapproves of any intrusion into his kitchen. This, and how things are solved, is *his* domain. All he wants from his master is a task and a budget.

The extreme externalist model of technology (c.f. Noble, 1977) is similar to the traditional one in the sense that goals are externally determined. But its serving character is more pronounced in that even the methods of technology are formed by external factors. Technology is nothing but a slave. The technologist is not only told what to do, but also how it should be done.

In this model, external interests have definite preferences as to the kind of techniques that are to be used. A certain age may prefer steam-power to horses and sails, not because steam-power is technically superior in solving transportation needs, but simply because steam-engines are in accordance with the spirit of that age: its status, culture and political interests. The task of the technologist is to solve all transportation problems with the help of steam-power. As pointed out above, practical problems can usually be solved in many alternative ways. You may fulfill needs of transportation with the help of steam, electricity or by splitting atoms, or you may choose between cars and roads, boats and canals, and trains and railroads. Given sufficient economic resources, ingenuity, political power and patience any of these techniques could be able to carry you wherever you wish. So why should not external factors rather than technical performance as such be decisive in the choice of technology? The extreme externalist model views technical development as a kind of mirror of society at large.

There is one major flaw in both models , which makes them less plausible as candidates for an accurate description of reality. The flaw concerns the technique-dependence of practical problems.

Let me illustrate this with an example. As a writer of this philosophical paper I am now fully engaged in the task of formulating my thoughts and communicating with my readers. A part of this task is clearly a practical problem: how should this communication be done ? To be honest this is not quite the way I *formulated* the problem to begin with. Actually the problem was: what do I write on my PC? And this in turn includes the following problems. Which buttons do I push in order to write this or that word? Which casette should I use? How do I save it? Which printer should I use? The latter kind of questions arise because I took the first one for granted, as a PC-problem. The practical part of my task was automatically formulated in terms of a computer-technique. But this has not always been so. Ten, and certainly fifteen, years ago the problem would have been: what do I write with my pen on this piece of paper? The writing process would have included a series of other problems, such as the following. How do I erase misspelling? How do I move this text from here to there? When should it be typed out on a typewriter? And these problems would have been thought of in terms of techniques such as pens, rubbers, scissors, glue and typewriters — a "prsgt-technique" for short. So, the original problem "how should this comunication be done?", was more or less automatically *formulated* in terms of a given technique. For me personally, during a dramatic period a few years ago, the old prsgt-technique was competing with the new PC-technique. The formulation of the problem was less automatic and I made a conscious choice. Still, there were certain aspects of the problem that were not questioned. The problem of communication was given in terms of print, paper and latin letters, not in terms of cave walls and painting-techniques.

My thesis is that practical problems are given, thought of and formulated in terms of the techniques that are intended to solve them. The problems encountered in our external activities have to be interpreted and this is usually done in terms of the techniques at hand. A hundred years ago our needs were expressed in terms of horses, steam-ships and telegrams. Today our needs are cars, airplanes and telefaxes. The practical problems we encounter in our daily lives concern such things as malfunctioning refrigerators, too slow computers and busted lightbulbs. Needs are perhaps not actually created by technology, but they are certainly dependent on a technical context.

This fact is not accounted for in the models of technology discussed so far. In both models it is taken for granted that external problems are present independently of technology. Technology is assumed to take no part in formulating its own goals. But an interpretation of the external problem is unavoidable. Technology does, and must, take an active part in this formulation. This brings us to the models above the horizontal line.

An autonomous technology (c.f. Ellul, 1964; Winner, 1977) defines its goals in terms of the techniques favored by itself. Techniques are not invented in order to suit a given problem. On the contrary, the problems of society are defined and formulated in order to suit a given technique. The extreme externalist type of technology was compared to a slave. An autonomous technology is its opposite. It is therefore appropriate to compare the latter with a slave-owner. But the actual slave-owner is a very special kind of person: the technocrat. The technocrat is a small soul camouflaged behind respectable and impressive clothes: science, technology and rationality. He believes science is a sufficient tool for telling him all there is to know about people's needs and wants. Protests and unexpected choices (if such are allowed) by individual users are brushed aside as signs of sickness and irrationality. The techniques that are offered are useful by definition. They cannot fail. If anything goes wrong, the technocrat blames the handling of the technique, or the user, or both. He is like the unpleasant doctor that you sometimes meet; a trained expert, certainly, but one who never listens and always knows what is best for you. Or like a Swedish politician, trained in social-political engineering since childhood.

The kind of technology described above is autonomous since the user has practically no influence at all. Technical development is purely based on scientific-technological criteria. However, according to the technocrat, technology is *not* developed for its own sake. There is simply no *need* for any external guidance.

The problem with this model is that it does not explain the existance of competing techniques. Trains compete with trucks, electricity competes with gas and combustion motors, nuclear power competes with water and oil, etc. And it does not account for the fact that technical experts often differ widely in their opinion of which technique one should apply. If technology could be chosen according to scientific criteria only, then there could never be rational disagreement, or rational competition. So, either we say that approximately half of the engineers in the world are irrational (or perhaps all of them are), or we take another look at the premises behind this model. For our purpose, the empirical evidence of disagreement and competition is sufficient for rejecting this model as unrealistic.

I call our last model the paraprax-model[3]. The term "technological paradigm" is sometimes used here. But this is just an analogy, and the differences involved are too great to call the analogous units in technology paradigms at all. To begin with, the central element of a paraprax is not a hard core of explanatory theories but of techniques. Techniques do not explain things; they solve practical problems. They make, move and transform things. Next we have a battery of help-techniques. Their function is to make the hard-core techniques applicable to a wide area of needs. A paraprax also includes a technical ideal, telling us the difference between good and bad technology and the difference between a good and bad solution to a given problem. In addition, the paraprax gives rise to a certain outlook of the world as such, giving us the means to interpret problems and to see potentials in terms of the hard-core techniques.

The main goal of the technologist is not to test the usefulness of various techniques in order to solve a given problem. As a member of a paraprax he aims at expanding its central technique. The technique is useful by definition. The main task is to reformulate new problems in such a way that they fit the paraprax, and to make other people see it as well. His technical work consists of *applying* the given technique, not in inventing new ones. The more established and powerful the paraprax is in society, the less he will have to spend time and resources on developing its technical side.

A good illustration of a paraprax is computer-technology. Its area of application has grown enormously since the 1950's. Originally a specialized technique for computation used for military and scientific purposes, computer technology is now used everywhere. This has been achieved through ingenuity, entrepreneurship and a host of help-techniques. For a member of this paraprax there is no limit to its applicability. Most practical problems are computer problems. If the service is bad at our hospitals, or if the frequency of accidents is too high on our railroads, or if people forget to lock their homes when they leave, then a computer or a new program is the answer. It is all a question of seeing the problem from the correct angle.

Other examples are the steam-engine, the combustion-engine, the technology of hybrid-DNA, various types of energy and materials. You may also find competing sub-parapraxes within, for example, medicine and education.

The paraprax-model differs from the autonomous one in that the choice of technique is not given by internal criteria. Rather, the technologist's choice of technology depends on competence, which usually depends on his education, which in turn may depend on things like expected income and opportunity. What external factors make some parapraxes successful and others not, will be considered in the following chapter.

Technological pluralism

The spirit of the age may also be a ground for explaining the existence and dominance of some parapraxes. But we have to be more explicit about the social conditions here. More precisely, we have to know something about the powers in society which make the existance and dominance of parapraxes possible.

One important secondary effect of using a certain technique is that we easily become dependent on it. Take for example the family car. After you have bought the first car you find many new uses for it, which you did not think of when planning to get one. Soon your normal life is adjusted to the new possibilities: your food budget presupposes the outlying shopping center, you buy a summerhouse at a nice spot away from where the main traffic goes and so forth. Your life is now dependent on the car, not because of some malicious properties of technology, but simply because a car is so very serviceable. Although a servant, it makes demands: you *have* to sacrifice time and money to keep it working. You simply cannot play with your kids as planned when the car suddenly breaks down and needs to be fixed. Without it, you will not get to your job in time from where you now live, and you cannot keep your food budget down.

What is our status now — slaves or free agents? The answer depends very much on the circumstances. If there were no alternatives to the car — no buses, no trains, no taxis — then the situation would be quite bad. The needs of the car would, at least in the short run, dictate our actions. On the other hand, if there were such alternatives, then we would be free to choose. We could, for example, take a taxi, play with the kids and have the car fixed later.

Hence, our status vis-a-vis a certain technique is very much dependent on the existance of alternatives, the existance of technological pluralism. In a technocratic society, only a few techniques would be allowed: i.e. those that were judged by the technical-political experts to be "objectively" the best. If these techniques, no matter how good they were, were given legal monopolies, then our relation to them would certainly be slave-like. Their needs would be prior to all other interests in society and our rulers would play the role of slave-owners. (Useful techniques make us depend on them, only men can make us slaves).

With technological pluralism we have less vulnerability and less reason to feel dictated. Of course, some techniques will still dominate in certain areas, simply because they are better than others. But as long as other alternatives have the legal right to be offered to us, our dependence can be handled.

For example: as a citizen of a welfare state I am more or less trapped when it comes to health care and education. Here we are offered "the one best solution" by our sovereigns and nothing else. However, when it comes to writing papers, home-cleaning, travelling and so forth, there are alternatives. The computer certainly dominates my own writing. I depend on this technique and I have adjusted my working routines in order to fit it. But since it is always possible to do my writing in the old "prsgt-way", I am not trapped. The computers are servants, and they serve me well.

Technological pluralism also solves a deep-seated problem of knowledge within technology: according to our definition, the concept of usefulness is relative to each user. Therefore, the technologist cannot by himself, in his laboratory, determine whether the technique he develops is useful or not. No objective standards and no internal measurements will give sufficient information. Part of the knowledge needed for a good professional's work is simply spread out among amateurs, i.e. among thousands of potential users.

This situation differs radically from that of science. In science, progress can and must be evaluated by the professional community. Theories are criticized and judged by the scientists themselves, not by amateurs. The reason for this is that the criteria for progress are objective, and not relative to individuals. But when it comes to the usefulness of techniques, the user cannot be ignored.

How well does the paraprax-model live up to the conditions given by the definition of usefulness ? The answer depends on the social and political situation for each paraprax. In a monopolistic situation the internal paraprax-logic takes over: external needs are not only formulated in terms of the paraprax, but these formulations are given an official sanction. "Education" is by definition precisely that which is given by the official school-system."Health care" is defined by the health care paraprax. In a pluralistic situation there is competition between parapraxes. This means that the user is offered more than one formulation of the problem. From the various definitions and various solutions the user is presented with, he is allowed to choose the one that he finds most suitable. The technologist does of course take active part in interpreting the problem for us, but his success depends on our choice.

Even if each member of a paraprax by definition views his own technique as superior he has no option but to accept the fact of competition. With technological pluralism, this includes not only existing alternatives but also potential ones. He is then forced to make his technique as useful as possible in order to survive.

It follows that the information needed by the technologist is — in a pluralistic situation — given to him through the choices made by the user. If the resources of the paraprax are dependent on how much a given person is prepared to pay — i.e. on how useful it is to him, given his personal situation — and/or on how many users there are, then this will determine the growth of the paraprax. The sucessful ones are the most useful ones. In a monopolistic situation this information is more or less blocked. In that case, the growth of the paraprax depends more on techno-political struggles than on its usefulness.

The behaviour and rationality of parapraxes change from one context to another. The more monopolistic the situation, the more the paraprax behaves like an autonomous technology. Within a pluralistic context, the parapraxes look as if technology could be described with a traditional or an extreme externalistic model. To any observer of technology who neither accepts technical development as purely irrational nor as purely rational, but sees both aspects, the paraprax-model may serve as a satisfactory step towards an explanation.

NOTES

1. The main ideas and concepts of this theory are further elaborated in Nordin, 1988.
2. Hence, I disagree with the suggestion made by Agassi,1975 that the guarantees made by various social institutions would be sufficient to give the "proof" needed. This suggestion is much too narrow also because a) there are no social institutions giving any guarantees within the R & D -work itself, and b) even a Robinson Crusoe would have to trust certain techniques.
3. The idea that problems are technique-dependent can be found clearly formulated in Illich, 1975; 1978. The external and non-monolithic character of technology is suggested by such authors as Feibleman, 1974; Wojick, 1979; Dosi, 1982.

REFERENCES

Agassi, J.
1975 Science in Flux. Dordrecht: Reidel.

Barrett, W.
1978 The Illusion of Technique. New York: Anchor Press/Doubleday.

Bunge, M.
1967 Scientific Research II. Berlin: Springer Verlag.
1972 "Toward a Philosophy of Technology" in C. Mitcham and R. Mackey (eds.), Philosophy and Technology. London: The Free Press.

Dosi, G.
1982 "Technological paradigm and technological trajectories". Research Policy, 11: 147—162.

Ellul, J.
1962 The Technological Society. New York: Vintage.

Feibleman, J.
1974 "Technology as Skills" in F. Rapp (ed.), Contributions to a Philosophy of Technology. Dordrecht: Reidel.

Illich, I.
1975 Tools for Conviviality. Fontana.
1978 The Right to Useful Unemployment — and Its Professional Enemies. London: Marion Boyars.

Kuhns, W.
1971 The Post-Industrial Prophets: Interpretations of Technology. London: Harper & Row.

Mumford, L.
1961 "Science as Technology". Proceedings of the American Philosophical Society, 105, 5: 506—511.

Noble, D.
1977 America by Design. New York: Alfred & Knopf.

Nordin, I.
1988 Teknologins Rationalitet (The Rationality of Technology). Stockholm: Timbro.

Rapp, F.
1981 Analytical Philosophy of Technology. Dordrecht: Reidel.

Schmookler, J.
1966 Invention and Economic Growth. Cambridge, Mass.: Harvard University Press.

Winner, L.
1977 Autonomous Technology. Cambridge, Mass.: MIT Press.

Wojick, D.
1979 "The Structure of Technological Revolutions" in G. Bugliarello and D. Doner (eds.), The History and Philosophy of Technology. London: University of Illinois Press.

Ingemar Nordin,
Tema H, University of Linköping
S-581 83 Linköping,
Sweden