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Separating Factual Disputes from Value Disputes in Controversies over Technology

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The social management of technology is, to a great extent, the art of resolving controversies over potentially risky innovations, such as nuclear power plants, supersonic airplanes, and the fluoridation of water. Opposing sides in these controversies typically disagree on matters of scientific fact as well as on judgments about moral and political values.

Some observers see benefit in separating disagreements over fact from disagreements over value questions. Factual disputes may be resolved by the analysis of data and so can be treated differently from value disputes which are impervious to the methods of science. For example, in the debate over nuclear power plants, scientific data could tell us whether or not X cases of cancer are likely to occur in a population exposed to Y amount of radiation, but they cannot tell us if X cases of cancer are an acceptable price to pay for the electricity which would be generated by such a power plant.

The Science Court

The "science court," which has been proposed by Arthur Kantrowitz and others, is one approach to the resolution of factual disputes after they have been separated from the value differences which are usually intermeshed with them.[1] Controversial issues would be referred to a science court by a means not yet specified, but perhaps

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through a request from a legislature or a suit in a law court or a referendum.

The procedure would begin with the selection of adversaries to represent both sides. The adversaries would be asked to state the scientific facts which they consider most important to their respective cases, and to supply documentation to support their assertions. They would then exchange their lists and documentation, examining each other's claims and specifying those assertions with which they agreed and those with which they did not. A referee who was acceptable to both adversaries would attempt to arbitrate differences between them, perhaps by alterations of wording or by the removal of ambiguities in factual statements. In the event that both adversaries agreed on all listed statements of fact, the procedure would end, and these facts would constitute the science court's report.

If one or both sides challenged factual statements by the other, these challenges would be the subjects of a hearing, open to the public and governed by a disinterested referee, in which the adversaries argued their opposing scientific positions before a panel of scientist-judges. The referee would restrict the debate to questions of fact, excluding issues of moral judgment and policy. The judges themselves would be established experts in fields which were relevant to the dispute, but would not be drawn from scientists actually working in the area of dispute, nor would they include anyone with a personal bias or organizational affiliation which would predispose him towards one side or the other. The judges would be subject to challenges by the adversaries on the grounds of prejudice, and the court would only proceed once a panel of judges had been selected which was acceptable to both sides.

After the scientific evidence had been presented, questioned, and defended, the judges would prepare a report on the dispute, noting points on which the adversaries agreed and reaching judgments on factual issues still in dispute. The judges might be able to decide if either or both of the adversaries were wrong, or if the differences between them were legitimate, resting on points of irreducible ambiguity or insufficient data. They might suggest specific new research to clarify points which remain unsettled.

It is important to emphasize that the judges would not make a recommendation on policy, or a judgment of moral right or wrong. Scientific judges are assumed to have no special wisdom that permits them to decide moral issues in their society. They should, however, be particularly qualified to arrive at purely scientific conclusions, and this would be the limit of their mandate. The court's report could then serve as the factual basis for value judgments by other bodies more properly charged with policy-making functions, such as the legislature or a regulatory agency or the public in the case of a referendum.

Other procedures, aside from the science court, have been proposed to treat factual disputes separately from value disputes. Barry Casper has suggested that the public would be better informed were the television channels to carry separate debates over the factual and the policy disagreement in such controversies, rather than intermingling them, as they do now.[2] Elite groups, such as professional associations, or seminars of scholars from the humanities as well as science and engineering, might improve their insights into these controversies by examining the value disagreements apart from the factual disagreements.

Separating Facts from Values

The classical argument over the relationship between facts and values has been extended to the science court with critics objecting that a clear separation is impossible. This argument has obscured more than it has clarified, since it suggests that a total separation of statements of fact from any evaluative statement is necessary for a science court. That is not true. All that is required is a separation of blatant evaluative or normative statements from statements of fact. Values which are shared by all the contending interest groups, or values which are too subtle to affect practical decisions, may be intertwined in the statements of fact without causing a problem.

A practical decision to build a nuclear power plant can easily be analyzed into factual questions, such as "How many cancers-per-year will be produced in the population exposed to radiation?" and in normative questions, such as "How many cancers-per-year should be accepted in exchange for the amount of electricity generated by this plant?" The problem is not so much that questions of fact and value are not empirically separable, but rather that an adversary may find it rhetorically useful to state his factual hypotheses in terms which make them difficult to evaluate. This point is best explained by the use of illustrations.

It is intrinsically difficult to demonstrate the absence of an effect or the impossibility of an event. An opponent of apple juice might argue that apple juice, consumed at the rate of five gallons per year per person, has harmful effects on the human organism. Proponents of apple juice would probably dispute this statement, which might then be argued before the judges of a science court. Consider now the positions of the judges: in order to reject the hypothesis, they must have evidence of "No effect" on all conceivable forms of mortality and morbidity. This is nearly impossible. Furthermore, even for the forms of mortality and morbidity which the defenders of apple juice did examine, the most that they would be able to say would be that they *discovered* no harmful effects, which is a weaker statement than that there *are* no harmful effects. The problem here is the intrinsic difficulty of proving the nonexistence of something—even if it does not, in fact, exist.

The report of the judges of a science court would certainly not affirm the dangers of apple juice, but neither could it reject the hypothesis outright. The report might, therefore, be interpreted as casting doubt on the safety of apple juice, even though there is no basis for such concern.

Adversaries might find it useful to state their hypotheses in vaguely probabilistic terms which contain no clear-cut criteria for realistic assessment. It might, for example, be asserted that "ionizing radiation probably increases all forms of cancer in humans." "Probably" is a vague term; judges have no clear criterion for deciding whether or not an effect is "probable." More precise criteria are easier to evaluate, but may sometimes be as misleading as vague terms.

Suppose the hypothesis had been stated as follows: "A population exposed to 170 rads/year of ionizing radiation will have significantly more colon cancers than a similar population not exposed." "Significant" has a precise meaning in statistics, i.e., that the probability of erroneous rejection of the "null hypothesis" is less than .05. If $p = .06$, then the null hypothesis is—in the technical sense—sustained, even though this result would clearly suggest that radiation actually did cause the cancers.

We must expect these kinds of rhetorical devices to appear in the factual statements which adversaries submit. For example, a scientist-opponent of the supersonic airplane has suggested that a science court examine this hypothesis: "In 1971 there was sufficient scientific evidence to establish *probable cause*. . .that 1.8 million tons per year of nitrogen oxides (as NO_2) injected by supersonic transports. . .at an elevation of 20 kilometers would reduce stratospheric ozone by. . .a global average of up to 20 percent. . . ." At first glance, this looks like a precise, factual statement. But the phrase "probable cause" is vague, with no clear criterion for deciding whether or not it could have been established.[3] Furthermore, the claim that ozone is reduced "*up to 20 percent*" is necessarily sustained with any reduction greater than 0%, no matter how small. In order to refute this claim, one would have to demonstrate the nonexistence of any reduction. Thus, the hypothesis has been stated in a way that there is little risk of the claimant being shown to be wrong.

It would be a great error to assume that adversaries purposively distort facts as a ruse to support their own positions, thought it would be naive to believe that this *never* occurs. In particular, it is wise to take into consideration the pressure on a technical expert who is engaged in a heated controversy, especially if he is opposing an "establishment" position with few resources of his own. There is a common tendency in such a situation to take a defensive posture, stating one's technical position in a manner that provides little opportunity for a clear refutation by the other side.

When such statements appear on both sides, as is frequently the case, the task of sorting out *who* is saying *what* is exceedingly difficult for the layman. The sophisticated judges of a science court would have an easier time sorting out the claims, but the difficulty of evaluating such statements is great. Obviously, if a science court is going to work, the substance of scientific dispute must be stated in a way which allows meaningful assessment through scientific methods. The same is true of any other procedure which requires the separation of factual disputes from value disputes.

The Role of the Referee

In the science court procedure, a referee has the task of obtaining factual statements with supporting documentation from the adversaries, determining which statements are accepted by both sides and which are not, and attempting to mediate differences between the sides. No doubt, much of the mediation will focus on problems of wording, such as are discussed above, so that the substance of the factual claims will be stated in a manner that allows fair assessment, allowing either a confirmation or a refutation by reasonable scientific means. It would appear that procedures other than the science court would have the same problem in separating factual disagreements from value disagreements, and, therefore, would require some mechanism in order to function as a referee.

Given the central importance of the referee function, it is disturbing that we have little sense of the feasibility of performing this role. The relationship between adversaries is usually hostile, and the referee has no sanctioning power with which to enforce the cooperation necessary for the production of workable factual statements. It would not be surprising, under these circumstances, to find that each side's statements are so "loaded"—so prohibitive to adequate testing—that the entire procedure falls apart.

In order to assess the workability of the referee's role, the authors attempted to promote an exchange between technical experts who were involved in a controversy over high-voltage transmission lines.

The Transmission Line Controversy

Citizens' groups in Upstate New York and in Minnesota are opposing the construction of new, very high-voltage transmission lines. As in most other technical controversies, objections include both technical and nontechnical issues. Opponents of the proposed construction are afraid that the lines are more dangerous than the utility companies realize, or will acknowledge, and there has been dispute over the magnitude of the hazards associated with extremely low-frequency electromagnetic fields of the type which these installations would produce. Technical presentations by both sides of the controversy have appeared in the permit hearings of the New York State Public Service Commission. More- or less-adequate summary accounts have been reported in the mass media.

Quite apart from this scientific issue, there have been objections to the use of the power of eminent domain by the utility companies to enforce the purchase of rights-of-way from farmers who are reluctant to sell sections of their land; this is seen as infringement of individual property rights. Other issues which have been raised are that (1) construction of the lines would promote the related construction of nuclear power plants; (2) utility companies do not serve the public interest; and (3) certain elected officials have not properly performed the duties of their offices. In Minnesota, particularly, there have been destruction of property and incidents of physical violence between the protestors and national guardsmen who were sent to protect the construction sites.

Becker, Marino and Mazur came into contact with the transmission line controversy along different routes. Becker and Marino have been actual technical critics of the lines, and have argued their case in public hearings and other community settings. Mazur has taken no position in the transmission line dispute, but rather has approached it as an opportunity to test the feasibility of the referee's role, as it is envisioned in a science court. To this end, Mazur attempted to act as a mediator between the opposing technical experts, who included Becker and Marino as the salient technical opponents, and four experts who were closely associated in hearings and published accounts with the argument that fields from the transmission lines are not hazardous. Mazur attempted to get fair statements of the disputed facts, and, in the process, acted independently of Marino and Becker. After the exercise was concluded, the three decided to join forces as co-authors in order to share the experiences learned during the dispute.

The Procedure of the Referee

Could a referee elicit from experts testable statements of alleged facts which seemed relevant to the policy issue, but were relatively divorced from strong value implications? Mazur, acting as referee, wrote to each expert involved, identifying himself as a nonpartisan, and explained his interest in the transmission line controversy as a test case for a science court; he enclosed an article about the science court from *Science* magazine. He asked for aid in constructing and critiquing a list of alleged statements of fact which are under dispute.

Most of the experts contacted did respond, although some of them required reminders before they did so. Most of them, apparently, read the *Science* article, and made some effort to construct or criticize the facts lists. However, only opponents of the lines produced explicit lists. The other experts cooperated mainly by providing critiques of those lists to Mazur, who then channeled them on to Becker and Marino. Becker and Marino prepared a revised list in response to the criticisms, and Mazur sent this revised list to other experts along with a request for comments. Three of the four experts who received the list responded.

Of course, this procedure was only a rough approximation of that which would occur in the initial phases of an actual science court. But it did carry out the crucial attempts to enlist the cooperation of experts who—in some instances—regarded one another with enmity, and also to obtain fairly-worded statements which would set out the areas of factual disagreement. What, then, was the result of this attempt?

Revision of the Lists

The strategy of Marino and Becker in compiling their original list was to assert first that biological effects from transmission line fields were *possible*, since they believed that at least one of the pro-line experts had maintained that such effects were not possible. This done, they then asserted that biological effects were not only possible, but *likely*. Finally, they argued that such likely effects cannot be shown to be safe (and therefore, it is inferred, may be dangerous).

Here are the explicit points of their argument:

1. Extremely low frequency (ELF) electric (and magnetic) fields *can* cause biological effects in human beings exposed thereto.
2. It is likely that ELF electric (and magnetic) fields associated with high-voltage transmission lines will cause biological effects in human beings exposed thereto.
3. No biological effect that is likely to occur in human beings exposed to the fields of high-voltage transmission lines can be shown to be nonhazardous.

This list was criticized by most of the pro-line experts as vague and untestable. The first statement, asserting that the fields *can* cause *biological effects* in humans, was criticized because they felt that the term "biological effects" is too broad to be meaningful in an empirical sense, given the wide variety of such effects which would have to be examined. Also, the statement that the fields *can* have effects is irrefutable, because opponents would have to show the converse: that fields *cannot* have effects. This is the problem of nonexistence which was discussed earlier. This same problem appears in the third statement which requires for refutation a proof of the nonexistence of hazard. The second statement maintains that field effects are *likely*, but there is no clear criterion for assessing whether or not an effect is "likely."

This initial list of statements shows the tendency—a common one in acrimonious dispute—to make ostensibly substantive empirical claims which are logically or pragmatically irrefutable.

To appreciate the impact of the exchange of statements and critiques among the experts, one must be aware of the fact that the opposing sides have had virtually no direct contact during their long involvement in the controversy (from July 1974 until the present), and they never before had been called upon to compare their scientific positions on a point-by-point basis. An important misconception soon became apparent. Becker and Marino had attributed to one pro-line expert the view that it was impossible to produce biological effects from low-intensity fields—a view that that expert denied to the referee that he held. Thus, at least one point of dispute was settled by the exchange.

Becker and Marino prepared a revised list in an attempt to respond to the critiques of the first list; this list appears in Figure 1. Here their allegations are phrased in the form of epidemiological hypotheses with a degree of specificity that is common in standard journals in that area. They alleged that people exposed to fields created by transmission lines (of a given design) for a period "as short as five years" will differ from a control population not so exposed in several enumerated characteristics.

People exposed for a period as short as five years to the electromagnetic field created by a 765 kV transmission line (as specified, for example, in "Application to the State of New York Public Service Commission for Certificate of Environmental Compatibility and Public Need," submitted by Rochester Light & Electric Corporation and Niagara Mohawk Power Corporation, January 1974) will be more likely to differ from a control population not so exposed in the following characteristics:

1. Growth, as measured by rates of change of physical parameters (e.g., height, weight).
2. Biological stress, as measured by physiological indicators (e.g., corticoids, serum proteins, circulating lymphocytes, blood pressure) and incidents of stress-related diseases (e.g., gastrointestinal and cardiovascular disorders).
3. Functioning of the central nervous and cardiovascular systems, as measured by neurohormone patterns, EEG, EKG, and the ability to adapt to blood volume changes.
4. Psychological behavior, as measured by decision-making capability, rates of acquisition of learned responses, gross activity level, reaction time, short-term memory, and motor coordination.

FIGURE 1. Revised List of Facts Relevant to Siting Electrical Transmission Power Lines Proposed by Drs. Robert Becker and Andrew Marino (4/7/77).

A refutation of this type of statement no longer requires the impossible demonstration that these fields *cannot* cause effects. An adequate refutation would consist simply of a comparison of exposed and unexposed populations and a demonstration that differences between them are no greater than one would expect by chance, using conventional levels of statistical significance. (The statement could be improved by specifying the details of such a study, including significance levels, which would be accepted as test criteria.)

Becker and Marino attempted to add specificity to their statements by listing four broad biological variables as effects and then giving specific indicators which are conventionally measured in physiological and psychological research on these broad variables. One such broad variable, and its exemplar indicators, is "Growth, as measured by rates of change of physical parameters (e.g., height, weight)."

One pro-line expert wrote that the revised list was still "almost impossible to judge. . .on the basis of current scientific knowledge or through a reasonable, empirical experiment." He suggested cogent improvements, such as a better specification of both the level of the electromagnetic field and the period of exposure alleged to cause effects. He also pointed out that the specification of exemplar indicators for the broad biological variables leaves uncertainty because, if no differences appeared on these exemplars, Becker and Marino could respond that additional indicators should be examined, and they would again be in the bind of having an infinite variety of indicators that might be considered. This expert suggested a complete specification of the indicators that would be examined; these modifications could be incorporated into a further revision.

Two other pro-line experts found the revised statement sufficiently specific that they could disagree that the allegations were true for humans. The fourth pro-line did not comment on the revised list.

The statement of alleged facts could be improved further, but there is little doubt that the revised list is a substantial improvement over the initial list. These results support the contention that a referee can obtain from opposing (and hostile) experts a list of alleged facts which are empirically meaningful, which are points of disagreement, and which are reasonably separated from the policy decision. In this case, the appraisal of biological effects from electromagnetic fields can proceed independent of decisions on whether or not to build transmission lines, or on levels of risk which are "acceptable" to the public.

Postscript

There is great irony in this largely-successful attempt to separate the factual disputes of the transmission line controversy from its value disputes. Once done, it was not possible to bring the experts together to debate their positions on factual issues; the pro-line experts as a group did not want any sort of involvement in a science court procedure.

Why were the pro-line experts reluctant to act as adversaries? One of them objected to the idea of a science court: "The concept of a 'Science Court' is foreign to the scientific method. . .", "the adversary approach. . .is anti-science." One of them objected specifically to Dr. Marino as an opponent, claiming that "his arguments and conclusions are sophistic."

Some of the pro-line experts thought that the public exposure of a science court was more likely to hurt than to help their side. One said that it "may impute scientific credence to Dr. Marino's arguments which they do not deserve." Another said that the transmission line issue should not be considered in an untried science court, because it might "go wrong." One wrote: "It would be unfortunate to find that, as a result of untested procedures. . .the science court might directly contradict the deliberate considerations of these same issues by well-established bodies such as the National Academy of Sciences. . .The potential impact upon the Nation's system of transporting electrical energy which might result from a Court decision inconsistent with those of other government agencies ought to be seriously considered in determining whether these issues are ripe for science court arbitration, particularly in the absence of any prior experience with such a court."

In the transmission line dispute, it is the proponents of technological development who object to a debate of scientific disagreements, in part, because it publicizes and perhaps legitimizes environmental criticism of the lines. Disputes wherein the publicity generated by a debate would exceed that already accorded the views of either party will probably be opposed by that party which perceives that it holds the advantage. Why, after all, enter the debate if it is more likely to improve the relative position of the other side than of one's own side?

This response emphasizes that many technical controversies are primarily disputes over political goals and only secondarily concerned with the veracity of scientific issues which are related to these goals. Why, then, should anyone care about resolving factual disputes? If the final report of a science court would probably not alter the positions of the adversaries and their interest groups, why bother?

One reason is that a reasonably sophisticated and relatively unbiased report on the factual matters in dispute could have an important impact on that portion of the public which has not yet taken a side in the controversy, but whose interests are at stake. If, in the controversy over the fluoridation of drinking water, a science court reported that there were, indeed, grounds to doubt the safety of fluoridation, then it is likely that previously uninvolved people would join the opposition to fluoridation in their communities. If the technical objections raised against transmission lines or nuclear power plants were found to lack any scientific basis, and this was reported by a credible source, then political power would most likely shift to the proponents of these technologies as electricity became scarcer and more expensive, and previously nonaligned citizens became involved. The resolution of factual disputes may not serve the interests of those directly involved in the debate, but it would be in the best interests of the public at large.

References

1. *Task Force of the Presidential Advisory Group on Anticipated Advances in Science and Technology. "The Science Court Experiment: An Interim Report," Science* 193 (August 20, 1976), pp. 653-656. Also see A. Mazur, "Science Courts," *Minerva* 15 (Apring 1977), pp. 1-14.
2. B. Casper, "Technology Policy and Democracy," *Science* 194 (October 1, 1976), pp. 29-35.
3. H. Johnston, "The Ozone Controversy," *Science* 191 (March 19, 1976), pp. 1125-6. A footnote adds, "In legal matters, *probable cause* is sufficient for a grand jury to recommend that a case be tried in a court of law, rather than be dismissed."