A SOCIAL PSYCHOLOGICAL ANALYSIS OF THE PRACTICE OF SCIENCE. THE PROBLEM OF MILITARY NUCLEAR WASTE MANAGEMENT

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ABSTRACT

The practice of science is theoretically self-correcting. But in the early 1980s, this aspect of science was not observed for radioactive wastes generated in the production of U.S. nuclear weapons. Instead, isolated from mainstream scientists, a self-regulated management practiced by Department of Energy (DOE) led to the mismanagement of nuclear wastes and to significant environmental damage. The causes of this damage, it will be argued, can be explained by an analysis of DOE self-regulation that encompasses structural, individual, and social psychological factors. It is concluded that, because DOE was isolated, a bureaucracy of DOE managers and scientists wrote radioactive waste management rules to protect their interests, recruited individuals who supported DOE managers and scientists, and constructed the perspective that DOE safely managed nuclear weapons wastes and protected the environment. This isolation prevented criticism from mainstream scientists, and blocked the self-correcting nature of science.

INTRODUCTION

This paper will be a brief case study of science as practiced in an applied setting. The objective of this analysis, using social psychology, will be to compare the practices of scientist in the mainstream with those in the management of nuclear wastes generated in the production of nuclear weapons by the Department of Energy (DOE). The management of these wastes, including treatment, storage, and disposal, has been the sole responsibility of DOE and its nuclear scientists and engineers in practices once considered by scientists to have been safe (1, 28, 30; in this study, scientists and engineers will be considered equivalent). Today, however, these practices are considered by these same scientists to have damaged the environment to the extent that DOE may spend more than $100 billion to minimize the damage and to comply with federal regulations (15, 32).

Despite the damage, in the environmental remediation underway DOE's focus has been to construct a public consensus on the use of technology to correct its problems, less so on changing the practices of its scientists (2, 11). Given that science is theoretically self-correcting (22), and that the DOE remediation efforts will be costly and lengthy, what causes corrections, its limits, and its relationship to a consensus should be analyzed. Otherwise, if science is not self-correcting, if scientific claims are resolved in the social context of justification, then science will be less able to maintain a privileged position and to claim an essential grasp of reality (10).

I will show that DOE management and scientists constructed a perspective, or world view, that led directly to DOE's mismanagement of nuclear wastes and to the environmental damage at its facilities. This perspective was constructed as an image of DOE as the successful manager of nuclear weapons wastes and of the environment (23). DOE presented this world view to both the public and to itself (26), an image that became an accepted part of its mission, expected and legally mandated by DOE and the American public (5). But this constructed image, accompanied by the scientific and public consensus that DOE was successful in protecting the public and environment, did not prevent or reverse the environmental damage at DOE sites; instead, by preventing a realistic assessment by DOE or by scientists independent of DOE, this image allowed additional damage to occur (13). If this conclusion is correct, then without a fundamental modification of its practice of science, DOE's recent attempt to construct a consensus for the development and deployment of capital-intensive new technology will be problematic, and, despite substantial preventative measures and costs, fresh environmental damage may result.

Whether or not DOE damaged the environment is not in question (15). But what let it occur, and why DOE scientists were unable to correct their practices before the problem became public, is in question. Further, the National Academy of Sciences was an independent reviewer of DOE programs. Why the Academy was not able to alert the public to the damage will be addressed. This analysis will also attempt explain why DOE scientists do not feel that the fault lies with them. This analysis will begin with a brief case study of radioactive waste management at Hanford, in Washington.

A CASE STUDY OF DOE

Radioactive Waste Management Technology is a means to control the environment for the benefit of civilization, but it becomes part of the environment after it is developed. Since control of the environment has been linked to the healthy behavior of individuals, the successful decisions of industry, successful corporate research, and the best science (7), the motivation to manage technology should increase with its growing presence or as it becomes less controllable. But as technology and civilization become more complex, the difficulty in the management of technology and its potential for widespread mishap should also increase. If this difficulty ever exceeded the actual ability to manage, as an alternative, an unchallenged management could instead present the appearance that its technology was being managed.

Since the 1940s, at 17 major research and production facilities that employ 100,000 and occupy an area twice the size of Delaware spread over 13 states, DOE has produced 60,000 or more warheads. Today, however, the emphasis has been forcibly shifted from the production of weapons to the management of nuclear wastes and to a major clean up of DOE facilities. The cause of this shift, given impetus by a reduced threat of nuclear war, is the public alarm at the magnitude of the environmental damage at these 17 facilities and the lack of a satisfactory solution to the disposal of radioactive wastes. For example, with only $24 billion in assets and an $8 billion annual budget, DOE faces the cost of a cleanup that has been estimated at more than $100 billion in a campaign expected to last more than 40 years (32).

Gen. Groves, in charge of the Manhattan Project in World War II, requested that Dupont construct the Hanford facility at a remote desert site alongside the Columbia River in the State of Washington (7). At its completion, the construction effort was hailed as a technological achievement. Despite this auspicious beginning, military radioactive wastes in America have been self-regulated--regulated without challenges from mainstream scientists. Until the mid-80's, radioactive waste management at Hanford exemplified the environmental damage caused by this DOE self-regulation. Generated in the production of plutonium, the largest fraction of Hanford wastes has been the liquid radioactive wastes pumped into the soil (210 billion gallons through 1984; 30). Although mostly lightly contaminated, the large volumes of plutonium-contaminated effluents led to one near criticality incident in soil containing more than 100 kg of plutonium (31). By 1982, at 370 individual sites at Hanford, liquid wastes containing plutonium had contaminated 12 million cubic meters of soil above a concentration of 10 nCi/g, or 3 million cubic meters above 100 nCi/g (9). This volume of plutonium-contaminated soil was 65 times larger than the total space at the WIPP repository in New Mexico. With no safe place to bury the plutonium-contaminated soil, DOE faced a dilemma.

At the same time, the most dangerous radioactive waste fraction at Hanford was the high-level waste that resulted from the reprocessing of spent fuel to produce weapons-grade plutonium. This high-level waste was stored in 175 tanks at Hanford (29). After a series of leaks of high-level wastes into the soil, 149 of the Hanford tanks had failed and were forcibly closed. However, in 1982, Congress passed a law that high-level waste had to be removed from all high-level waste tanks, solidified, and buried deep in an underground geologic formation. Since, the waste in those 149 tanks could not be removed, DOE faced a second dilemma.

These two long-standing problems, well-known to DOE and the Academy, meant that DOE could not satisfy either its 1973 rules for military radioactive wastes (24), or the 1982 law for high-level wastes (25). The DOE self-regulation led to this predicament, but it also provided a solution. Without public notice or independent scientific validation, DOE scientists and managers revised their rules for radioactive wastes (28). First, the definition of plutonium waste was changed from 10 to 100 nCi/g. Consequently, without removing any plutonium from the soil, between 1981 and 1984, the inventory of plutonium-contaminated soil at Hanford went from 12 million downward to 30,000 cubic meters (27, 29).

Second, high-level waste in the 149 tanks was redefined as a combination of transuranic (mainly plutonium) and fission products (28). While not readily apparent, the key to differentiating between transuranic and the less restrictive category of low-level radioactive wastes was the way that DOE scientists determined if plutonium waste was transuranic. In their calculations, the weight of the radioactive waste matrix (plutonium plus debris) and containment (shielding) were included in figuring the concentration in the transuranic waste category. Compared to the plutonium present, the more the weight of the debris and containment, the less became the calculated concentration in the category of transuranic waste.

Since the 149 tanks at Hanford were partly empty, a plan to add superfluous rocks and cement to these tanks, in effect creating more radioactive waste but at a lower overall concentration, plus including the tank's steel and cement exteriors, allowed DOE to reclassify the total tank contents as low-level waste, a much less restrictive category than either high-level or transuranic waste. By redefining its high-level wastes as low-level wastes, none of the tank contents had to be retrieved, and the failed 149 tanks were then planned by DOE to be left alone (28). There matters remained until public criticism forced DOE to agree to remove the wastes from the 149 high-level waste tanks at an estimated cost of $17 billion (16, 30).

SOCIAL PSYCHOLOGICAL ANALYSIS

To begin with, two arguments could be made to explain DOE's problems with nuclear wastes. It could be argued that DOE scientists were deficient in their expression of ethical values. This argument derives from a philosophy of universal moral values, or from an ethology of individual differences along an ethics continuum, emphasizing the value of ethics independent of context. Alternatively, an argument could be made that DOE scientists were in a context that prevented their perception of the environmental degradation. While both arguments are plausible, the latter is stronger because it controls for individual differences, such as ethics, and because causes can be attributed to situational or structural factors. An analysis of the entire context would include the knowledge that DOE scientists and engineers believed that their ethics were not compromised, that they did an excellent job of protecting the environment (26), and that the blame should be placed elsewhere. For example, Alvin Weinberg, past Director of DOE's Oak Ridge National Laboratory, assigned responsibility to a public -- emerging from anxiety in the wake of Three Mile Island, Bhopal, Challenger, and Chernobyl -- fickle and ill-informed by its loss of confidence in modern technology (33).

Guided by this strong argument, the environmental damage can be linked to three factors that constructed the world view of DOE scientists: structural, selection, and social psychological variables. First, in the interests of national security, the DOE structure and culture emerged from its nuclear weapons mission (5), which led to the formation of an authoritarian, centralized bureaucracy with well-defined roles and behavioral norms. For instance, research topics were not freely chosen by individual scientists, but were negotiated between DOE and DOE contractor managers and assigned to research teams in exchange for findings that supported DOE public policies. These exchanges, as would be predicted by an analysis of organizational communication (34), gave direction to DOE scientists, and certified the authority and central control of DOE management over its scientists. Since the research results could not be released until after they had been approved by DOE, these exchanges affirmed the status and power differences embedded within the management hierarchy and then between management and its scientists. Further, if the results from research indicated that the criteria for the management of nuclear wastes were not being met, then the rules could be changed to provide the appearance that the criteria were being met (24, 28).

Second, the scientists attracted to classified, nuclear weapons work led to the selection of those seeking the success available from a DOE bureaucracy protected from the competition of mainstream science. In particular, those selected into the inner circles that shared power were chosen based on their similarity to managers, their ability to validate management's world view, and their ability to form alliances that strengthened management's power in exchange for an increasing share of power and control over their own research programs (8). The result was a performance niche characterized by increased abilities to control access to rich resources and to reciprocally deploy protection to the members allied to protect the niche, such as by marginalizing the opposition by redefining the governing rules.

Third, the preceding structural and individual levels can be brought together in a social psychological analysis of the perspectives that emerged in the day-to-day practice of science within DOE. The DOE formal structure guided selection practices, goals, and allocated responsibility, but the structure also included the means for the individual to satisfy both role requirements and individual goals (8). One path to the fulfillment of individual self-interests, and a contribution to the formation of a consensual world view among DOE scientists, was through the perception of reality. Supporting the world view of DOE scientists that nuclear weapon wastes and the environment were being safely managed benefitted management and younger scientists adroit enough to exploit alliances with managers in positions of power, producing an interlocking, cohesive world view that strengthened the organization against external forces and internal change.

In turn, the management-scientist alliances incurred obligations discharged by guiding the scientific practices in the collection, interpretation, and explanation of the data on the effects of nuclear weapon wastes in the environment in a fashion that supported the world view of DOE managers. But with the accrual of environmental damage, this view of reality became problematic, so it was justified by the funding of major DOE research programs that repeatedly affirmed that the environment was properly managed (3), and by covering up information that indicated significant environmental damage (13).

Finally, the isolation of DOE from mainstream science prevented external challenges that blocked the self-correcting nature of science. Although the National Academy of Sciences had technical oversight of selected DOE radioactive waste management programs, that oversight was limited because the Academy projects were funded by DOE, and because DOE selectively provided data to the Academy. In one example, the Academy and DOE studied radioactive waste management at the Savannah River Site. Although the DOE study reported significant environmental damage (12), the Academy found negligible environmental damage (21). In their study, however, the Academy had not been aware that DOE used two data sets for radionuclide contamination, one published in the public domain, the other for the private use of DOE scientists.

DISCUSSION

Instead of being exhaustive, this study was intended to integrate the underlying causal mechanisms of the processes involved in the formation of a perspective by DOE scientists. The DOE case study helped to achieve this integration by allowing an analyses of the practice of science within DOE on different levels. These different levels -- structural, individual, and social psychological -- provided an understanding of the causes of the environmental damage confronting DOE. The case study showed that structure and individual factors combined to form a dynamic system that produced a DOE culture and a stable world view, that the world view and the culture were resistant to change (15), that structural variables constrained behavior and organized the self in line with the world view, but that because the system was dynamic, the DOE structure would evolve over time to continue to allow an interpretation of the evidence to conform to the world view.

The world view of scientists is received by initiates in a scientific society who become acculturated to the view, and then guides their behavior. Scientists are motivated to align their perspectives of the world with the received view. Such motivations are grounded in their desire to control the proximal world that consists of research programs, budgets, laboratories, and personnel, but also personal and professional outcomes as well. Threats to these resources, in the form of research outcomes aversive to management, or threats to the world view (6), should be met by self-serving strategies that resolved the threats, and protected the established order.

The DOE case study demonstrated why the science practiced in DOE was not self-correcting. Secrecy and national security concerns removed DOE scientists from the mainstream of science and from the possibility of confrontations with a skeptical minority of scientists. This isolation removed obstacles that DOE scientists may have had against their alignment of their world view with the corporate interests of the bureaucracy. Over time, once the DOE world view successfully protected and provided scientists with the resources to implement their research programs, once the world view became a device to frame and control the environmental evidence, scientists automatically avoided or discredited negative findings, and sought positive findings that converged to support the world view of DOE management (14).

The DOE case study also illustrated the importance of alliances. Alliances are formed to gain power, but for those inside of an alliance, impression management and expectancy effects become important factors. Thus, when the evidence became overwhelmingly obvious to scientists and managers that DOE could not comply with its own rules for radioactive waste management, the resources at risk increased the likelihood that an unchallenged DOE would continue to manage the impression that it could protect the environment. These impressions were sustained by DOE managers whose expectations were fulfilled that they could obtain a favorable consensus among its different alliances with DOE scientists, whose research budgets were at stake, to change the rules to protect DOE's public image. It was not a coincidence that rules over time became less stringent (28), that DOE satisfied its public and legal commitments with new rules, but that the environmental degradation continued and increased despite new rules (15).

Generality of the Analysis. This study began with the question that if science was self-correcting (21), why was DOE unable to find and correct its problems over the past 50 years? The DOE case study indicated that, for DOE scientists, many scientific claims were resolved in the social context of justification (10), that DOE science was not based on absolute truths, and that DOE science should not be accorded a privileged position in the sense of claiming an essential grasp of reality. But, if nuclear scientists in DOE resolved differing claims by resorting to discretionary judgments, to what extent is science ever self-correcting?

First, the finding that the research of DOE scientists was constrained to fit the needs of DOE management is not unusual. Other examples of research doctored for the benefit of managers are available. A sample of these cases has found that management at the Department of Agriculture doctored a scientific report's conclusions to agree with agency policy (17). The staff at the National Academy of Sciences doctored a report on vitamins to fit a public Academy policy (18). Executives at Northrop falsified missile test data (20). And, after the 1957 mishap at Windscale, the British government withheld findings from the public to defend the image of Britain's young nuclear industry (4).

Second, much is made of the need for a consensus among scientists and the public (11). However, the consensus among scientists of earlier ages for Aristotle's force of impetus, similar to the intuitive physics used by ordinary people to explain the motion of objects (19), did not make the force true. Nor did the long-standing consensus among DOE scientists that the environment was being protected make it true. When theories can neither be confirmed nor disconfirmed, any desired view of the world can be held, including a consensus.

But there is a limit to the subjective force of science. Technology cannot be developed with the guidance of just any theory, or any consensus. Neither is science solely a social fabrication. DOE scientists daily made predictions that did fit independent observations in the world. Dupont scientists at the Savannah River Plant built a new technology, a plutonium production facility, operated it for many years, and garnered numerous awards, including nominations as one of the safest industrial facilities in the world. In 1951, the existence of the neutrino was confirmed at Savannah River. Thus, the effects of subjective science may range from nil, when the evidence withstands strong challenges, to a maximum, where the data is uncertain. For evidence that is uncertain, reasonable challenges to strongly held views become difficult if the evidence is isolated from mainstream scientists, and when the conclusions from that evidence are supported by DOE scientists and the National Academy of Sciences.

CONCLUSIONS

The thrust of this study has been to apply social psychology to the practice of science, but in the process, the importance of world views was underwritten. Perceptions may be fundamental to an explanation of how behavior is guided, especially when the perceptions become strongly held world views as they are likely to be for scientists. Research does not indicate the conditions or extent of this robustness, but Greenberg and his associates (6) believe that threats to an individual's world view will reduce self-esteem if the threats are not defeated, and will increase attachment to a group, to an organization, or to a perspective if the threat is defeated.

Finally, what has been learned in this study can be applied to understand the public's reactions to nuclear technology. DOE scientists and engineers are disturbed that the public has lost confidence in them, and have blamed the loss of confidence on a public that is fickle and ill-informed (33). But when the public came to believe that nuclear waste technology was out of control, it threatened the world view that those scientists had constructed for the public. And when a world view is threatened, it leads to a loss of public trust in the group responsible for the threat (6). How to regain public trust? Instead of a public consensus that may only be artful, a more substantive method would be to improve the practices of DOE scientists and engineers to gain effective control of the management of radioactive wastes. With success, over time a consensus would form to support that management.

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