Radiophobia and how people think about radiation

D. M. Wood, August 2023

"Never confront feelings with facts.".
"Perception is reality."

Contents

2023 Preamble

Our original document dates to 2017. It has been revised to include more recent work on 'radiophobia' and its consequences and to older quotes trimmed. Since 2017 there has been an explosion of concern about public vulnerability to misinformation and disinformation (for example, via social media) which is considered elsewhere on the website. As nuclear power becomes more attractive as a means of slowing global warming, confronting radiophobia becomes more urgent.

Introduction

Nuclear radiation is mysterious, even uncanny since invisible. Its connotations are almost uniformly negative—the deaths of hundreds of thousands of people in Hiroshima and Nagasaki and the lingering stigma for victims even in Japan. Current associations are with nuclear

accidents: Chernobyl and Fukushima, or the fact that nuclear waste will remain dangerous for thousands of years, far longer than our civilization is directly able to comprehend. For some, the topic is fraught with suspicion because of mismanagement of nuclear accidents: who can I trust for reliable information?, or the fact that the exploitation of nuclear energy lay for many decades firmly in the hands of the military-industrial complex. In 2023, by contrast, there are several commercial initiatives to bring small (and even portable) fission reactors to market.

Like nuclear radiation, electromagnetic radiation is often also invisible but is familiar and less intimidating because of its usefulness—medical X-rays, microwave ovens, radio, TV, cell phones, WiFi. Both sorts of radiation must be understood mathematically either to exploit them or to protect ourselves from undesirable side effects.

The human costs of 'radiophobia'

An excellent recent overview

The article *Radiophobia: Useful concept, or ostracising term?* [1], written after the beginning of the Russian-Ukrainian war, serves as an update and introduction to older work described later in this document. No one curious about (nuclear) radiation and public perception can afford to overlook this article. The abstract notes that the term radiophobia "…has been used extensively to dismiss fears of radiation as being emotional overreactions to a risk that is actuarially very low, stemming from public ignorance." and

> …whilst its often ostracising usage towards the public should render the term obsolete, radiophobia can still be regarded as a useful concept to try and explain the extreme risk perception divergence that exists between nuclear experts and the public. However, in order for a more constructive nuclear discourse, a paradigm shift will be required, acknowledging the complex historical and sociopsychological factors that have shaped radiation into becoming a uniquely feared process. Such an acknowledgement will likely be a prerequisite for any efforts towards normalising humanity's relationship with radiation, and would require considerable changes in communication practices.

The article begins

> Suicides, abortions, stigmatisation, depression, anxiety, bullying–the consequences of radiophobia are significant and can be severe … very little progress towards resolving it has been made. This became especially evident during and following the Fukushima Daiichi accident in 2011, highlighting a systemic failure to get to grasp with the concept of radio phobia, and its psychological roots.

They note

> Despite considerable efforts having been dedicated to attempt to alleviate public concerns about any potential health consequences of exposure, it is evident that this has not been successful. Indeed, it is rather remarkable that more than 125 years of public awareness of radiation has not translated into any major shifts in its risk perception profile.

and

> An important factor explaining the emergence and subsequent stability of radiophobia is the fact human perception is largely blind to probability. Instead, the possibility of a risk materialising is a significant driver in terms of perception. In the case of radiation, the mere possibility that radiation exposure—irrespective of the actual dose—can cause cancer, congenital defects, and hereditary impacts, is enough to shape public perception to such a degree where these outcomes become virtually certain if exposed. Once such a notion has become embedded within both an individual's mind and in the broader collective narrative, it becomes very challenging to dislodge it.

On the subject of the 1986 Chernobyl accident, they observe

> The perceived congenital risks—which acts a powerful fuel for radiophobia—has also had negative consequences on those who were evacuated from Chernobyl as infants (or whose mothers were evacuated whilst pregnant) self-rated their health as more negative than their non-Chernobyl peers, even though there were no actual health differences (Bromet et al., 2009). This discrepancy was linked with health risk perceptions, which inevitably is directly connected with radiophobia. This discrepancy does, however, manifest in other guises and outside of the nuclear power or nuclear weapons context.

Finally, they note

> This means that any communications strategy should stress the benefits of the technologies which, in turn, should be supported by (positive) affective imagery. Replacing the imagery that radiation has become intimately associated with will take time and significant efforts, as during the last seven decades radiophobic discourse has largely been allowed free rein. Whilst climate change has, prima facie, given nuclear power a new lease on life, it is far from certain that it will yield the changes required in terms of imagery to revert radiophobia. Indeed, some studies have found that the nuclear power-climate change coupling results in "reluctant acceptance", with nuclear power only being embraced as a matter of last resort.

Radiophobia and specific biological concerns

A second recent *Health Physics* article, *How the Science of Radiation Biology Can Help Reduce the Crippling Fear of*

Low-level Radiation [2] addresses particular biological concerns. It is very important to remember that to *oncologists* a large radiation dose may be 50 Gray units (energy deposited per unit mass, 1 Gy=1 Joule per kg) and thus a 'small' dose is 1 or 2 Gy. To most *non*-oncologists a small dose is roughly 0.1 Gy, and the annual doses from natural sources is typically measured in tens of milliGy. The relevant yearly doses around Rocky Flats are about 2 μSv ('microSv') due specifically to plutonium in soil.

As you can read in other documents on our website, equivalent whole-body radiation doses are often measured in 'Sievert' units. For X-rays or gamma rays, 1 Sv = 1 Gy.

This 2023 article provides a somewhat technical background to specific health fears of radiation. More importantly, it asks *and answers* a number of questions that often deeply concern the public, citing recent work on each topic. Precisely because of this format, we will not review these questions in detail, but will link to the document in the Frequently Asked Questions part of the website. A few particular observations from the paper are

- *Cancer risks* "The take-home message from the early results of the Million Man studies is the apparent absence of a relationship between radiation dose and radiation-induced cancer in some important populations. These include the atomic veterans, nuclear navy, and nuclear power plant workers."
- *Genetic risks:* "... the risk from radiation-induced genetic effects is much less than the risk from radiation-induced cancer". In an animal study, male mice received 2 Gy doses (close to the level that would cause sterility) and permitted to breed with unexposed females. The process (2.0 Gy dose, breeding with (different) unexposed fmealesh, then monitoring of overt quantities such as litter size, fetal deaths, abnormal offspring, weight, coat color) was repeated for 20 generations. There were no signs of any cumulative genetic damage.

Biases and mis-perceptions of risk

Before embarking elsewhere on an examination of the process by which Rocky Flats (the National Wildlife Refuge and the areas around it) is judged safe to live around and to visit within, it is very helpful to examine our biases.

An excellent 2010 article by Britt-Marie Drottz-Sjöberg and Lennart Sjöberg entitled *The perception of risks of technology* [3] examines public perception of radiation from a Swedish perspective, informed as well by American sociological work. In keeping with the intent of this web site, this article is useful because it provides *data* (figures and tables) and brief, clean explanations, on how people perceive risks around radiation.

- . . . Many risk debates are about very small risks, and in such cases we are not greatly helped by intuition. When the risks are quite small, we usually have no direct personal experience of them. It is also in many cases quite problematic to determine the real or objective risk, especially in the case of very small risks. People have different opinions about risks. Experts, in particular, can make estimates very different from those of the public, especially with regard to risks within their special areas of expertise and responsibility.
- Experts usually consider risks to be very much smaller than the public does, but there are exceptions. They may indeed sometimes consider risks to be larger than the public does, as in campaigns aiming to help people stop smoking or to test their homes for radon. Such campaigns are usually not very effective.
- It seems that experts make lower risk assessments in the case of hazards within their own area of responsibility, but not otherwise.
- In the case of a controversial topic such as nuclear waste, the differences between experts and the public can be enormous.
- There now seems to be no strong and pervasive relationship between media exposure and risk perception.
- At the end of the 1960's, Chauncey Starr showed that risk acceptance seems to be dependent not only on the size of a risk but also on other factors, the most important, in his view, being voluntariness It seemed that the public is willing to accept a risk level in private automobiles which is 10 times higher than that in professional road traffic (taxis and buses). At that time, at the end of the 1960s, nuclear power was the prime reason for interest in social science risk research. The risk of a major nuclear accident was very small, according to experts. Yet, the public was unwilling to accept nuclear power. Why? Maybe Starr was on the right track with his concept of

voluntariness. People may have experienced nuclear technology as being imposed upon them without their prior consent.

- In 1978, an important paper was published by Baruch Fischhoff, Paul Slovic, and colleagues. This work was based on a compilation of factors which had been suggested in the discussion following Starr's article. The authors showed that people could make meaningful judgments of risks according to a number of dimensions which could then be reduced to three underlying factors, namely "number of affected," "dread," and "new risk." This was the basis of the psychometric model of risk perception. Its dimensions could well explain average judgments of risks of a large number of hazards. Nuclear power was regarded as being both new and dreaded, and hence there was support for explaining opposition to it as based on emotional and irrational factors. This was probably also in line with how supporters of nuclear power regarded opposition to it . . .

  The psychometric model must be taken with a large pinch of salt. It is easy to explain average values of perceived risk, but it is much harder to explain the risk perception of individuals. . .

  The model can be improved by the incorporation of new dimensions. One such dimension is "interfering with nature." This factor also includes moral aspects. . . . At the same time, when "interfering with nature" is added, the traditional explanatory factors lose much of their explanatory power.

- . . . Opposition to nuclear power was explained in a way that seemed plausible to many. However, when the set of explanatory factors is extended, it appears that reactions to technology have more to do with ideology and morality and ideas about "nature" than anything else.

I have displayed in a graphical way in Fig. 1 results from a table in their article which shows how surveyed Swedish citizens perceived a number of concepts or ideas along a 'natural/unnatural' axis. It is clear that while technological development is considered by most people to be a natural process, vaccines and X-ray diagnostics are not, and radioactivity is definitely not. Thinking about genetically modified fruits and irradiation of produce to preserve it is almost black and white. The authors continue,

- Most studies of risk perception show that it is more common to deny risks than to be very worried about them. However, worried people make themselves heard more frequently. They seem to have a greater tendency to be active. Maybe their opinions are also more interesting to the media.

- Those who are active in a risk debate, e.g., those who are for or against a local nuclear waste repository, tend to have more extreme views than people in general. These groups belong to the so-called stakeholders. Corporations and authorities can easily get a biased

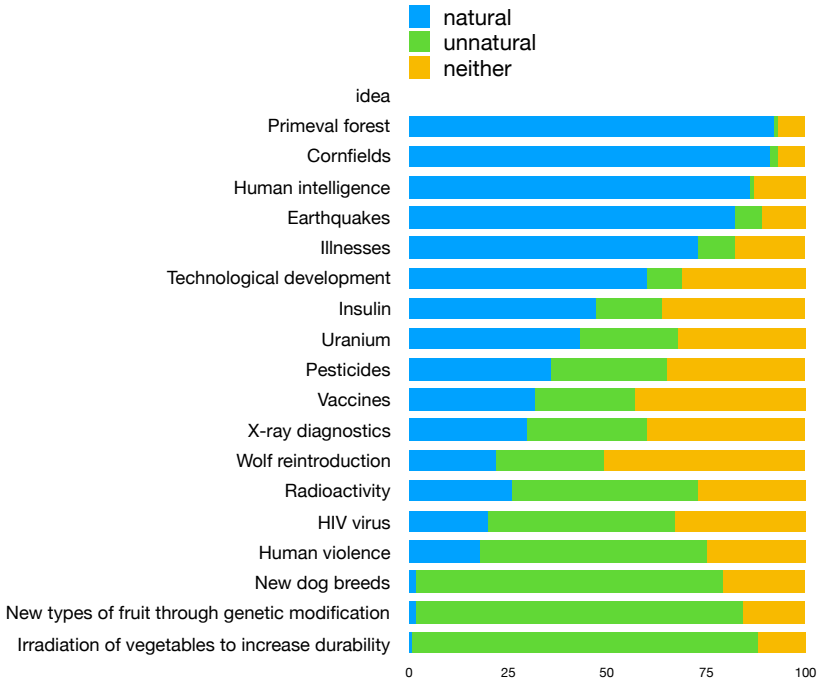

Figure 1: Public perception of the 'naturalness' or 'unnaturalness' of a number of ideas or concepts. Data from [Drottz-Sjöberg B-M (1994), *Experiences of nature and the environment*, Rhizikon: Risk Research Report, No. 21. Center for Risk Research, Stockholm School of Economics, Stockholm, 1994.]

view of public opinion if they listen mostly to active groups, which are those most likely to voice their anxieties and get in touch with organizations responsible for risk management. This is an important reason for making surveys of the risk perception of the general public, not only case studies of active persons or groups.

- Risk denial is an important phenomenon. Lifestyle risks are perceived to be important for others, but not for oneself. Every doctor has encountered patients who come too late for help, because they have disregarded symptoms and told themselves, for much too long a time, that they do not have a serious illness.
- Gender is an especially important factor in risk perception. Women tend to judge risks higher than men do. Ionizing radiation is a very clear example. Women tend to judge risks as larger especially if they concern risks to others. There is a gender difference also with regard to personal risk but it is only about half as large. Education and socio-economic status (SES) tend to be of importance as well. People with a higher education and a higher SES tend to judge risks to be smaller. The reason could be that such people are in fact exposed to smaller and fewer risks, or that they believe they have a better opportunity to protect themselves against risks. American studies have shown a "white male effect." Afro-Americans and white women judge risks to be greater than white men do. This effect does not have an analog in the effects of SES in Sweden: a low SES is associated with larger perceived risks in both men and women.
- What is the importance of risk perception? It is often assumed, more or less implicitly, that perceived risk is a major factor behind

demands for risk mitigation: The greater the perceived risk, the greater the requirements to mitigate it. This should be true both for insurance decisions made by consumers and for voters' requirements to phase out a technology which they see as too risky. This is a simple and self-evident approach, and much of risk debates seem to support it. But the matter is not quite that simple.

- Some time ago, everyday and banal risks were included in the list of hazards investigated. This was an unusual approach. Almost all earlier work had been concerned with fatal and catastrophic risks. The results of the study were that some trivial risks were judged as larger than some of the serious mortal risks. The risk of catching a common cold was seen to be greater than the risk of being infected with the HIV virus! But, at the same time, we require protection from the HIV risk, rather than from the common cold. This result calls for some new thinking about risk and policy.

  If you ask people to judge the probability of injury, the size of the consequences, and the size of the "risk," it is found that risk and probability correlate very strongly and seem almost to represent the same concept. The demand for risk mitigation has little to do with risk and probability, and much more to do with the perceived consequences. It is possible that these results are related to the fact that "probability" is a concept which it is difficult to understand, and that very small probabilities in particular are hard to grasp intuitively. Small probabilities are also difficult to determine because there is little or no empirical evidence to build upon and they have to be estimated with the help of models. Models can be questioned because they are based on assumptions. It is difficult to retain credibility in such cases, if risk assessments are challenged.

- Demand for mitigation has economic consequences. If a risk can affect children or handicapped people, we are willing to allocate more money towards mitigating it. For adults who are capable of dealing with risks, or should be able to do so, we are less willing to mitigate risks at the expense of society. The sum of money spent on "saving a life" in different sectors of society has been calculated in several countries, among them Sweden. When children are concerned, it can amount to hundreds of millions of SEK per life, and likewise for some especially dreaded types of illnesses and accidents. . . . It is very hard to understand the large variation in implicit life values calculated in this way, even if some of the dynamics can be imagined. Is suicide a type of risk? Society has a low level of interest in suicides and many people would argue that it is a matter for the individual. It could even be argued that it is a human right. It is a very different matter with children's suicide, or preventing accidents where children may be involved. In these cases, society is willing to allocate large resources to "save a life."

SEK = Swedish Krona $\simeq$ $ 0.15 in 2010.

There has been recent work on a specifically American "conservative white male"(CWM) effect [4] "... we expect that a CWM model would be more powerful than a WM model in explaining perceived risks of those environmental, technological, and public health hazards whose solutions most clearly necessitate governmental regulations on industry and personal behavior."

Section below discusses some current realities about the gap between 'experts' and 'non-experts'.

Persistent reliance on outdated information

A useful 2017 article by Pluviano, Watt, and Della Sala [5] examines another form of bias, associated with an inability to update memories in light of revised information. They note that

> Classical laboratory research on memory for inferences demonstrates that the continued reliance on discredited information is very difficult to correct. Even when people clearly remember and understand a subsequent correction when asked about it immediately (suggesting that they have encoded it and can retrieve and potentially comply with it), they can still be influenced by the effect of the retracted misinformation. That is, people are susceptible to misinformation even though they had acknowledged that the information at hand is factually incorrect. As Rapp and Braasch stated "the problem is not just that people rely on inaccurate information but that they rely on it when they seemingly should know better". This seemingly irrational reliance on outright misinformation has been demonstrated with beliefs related to well-known material (e.g., biblical narratives), blatant hoaxes (e.g., paranormal claims) or personally experienced events (e.g., distorted eyewitness testimonies). It also occurs despite measures intended to make the presentation of information clearer and despite explicit warnings about the misleading nature of the information at hand. Therefore, simply retracting a piece of information does not stop its influence because outdated pieces of information linger in memory. In the case of vaccines, providing evidence about the safety of immunisation may not be enough as people may have heard or read somewhere that, for example, vaccines are not necessary, that they cause autism or contain dangerous chemicals.

An interview with an Ars Technica writer [6], noted: "People tend to mistake repetition for truth, a phenomenon known as the 'illusory truth' effect," the authors . . . note. And when those myths are built into a framework of beliefs and world views—a cognitive consistency perspective—it becomes even harder to knock them out."

Suspicions about science and scientists

Especially in recent years, a widening gap between the views of scientists and the public has become apparent. The Pew Research Center (well known for its surveys and polls) has documented [7] large gaps between the opinions of scientists (using members of the American Association for the Advancement of Science as a proxy

for all scientists) and ordinary citizens on a variety of science, engineering, and technological issues.

Despite general confidence [7] in the benefits of science and technology to American society, there are substantial differences in how scientists and the public perceive risks due to, for example, genetically modified food (a 51% gap!), the use of pesticides, the advisability of requiring childhood vaccines, the importance of human activity in climate change, and the advisability of offshore drilling. These are mentioned because a suspicion about technology and a vulnerability to repeated mis-statements becoming 'fact' continues as a persistent theme from the earlier work above.

This 2015 report also finds that

> Compared with five years ago, both citizens and scientists are less upbeat about the scientific enterprise. Citizens are still broadly positive about the place of U.S. scientific achievements and its impact on society, but slightly more are negative than five years ago. And, while a majority of scientists think it is a good time for science, they are less upbeat than they were five years ago. Most scientists believe that policy regulations on land use and clean air and water are not often guided by the best science.

The obligation of scientists to communicate clearly and respectfully to the public is discussed in an excellent blog by Andy Hoffman [8] entitled *Science communicators or science mediators*. It is possible to interpret the gaps mentioned above as a failure to *communicate* not just the 'facts', but most especially the *process* by which science reaches conclusions or at least consensus. He states

> There are others who subscribe to a view of scientism that elevates the natural sciences in relation to all other ways of knowing the natural world and holds "the view that the characteristic inductive methods of the natural sciences are the only source of genuine factual knowledge and, in particular, that they alone can yield true knowledge about man and society." They are dismissive of the arts, the humanities, religion, and pragmatic experience as ways to know and understand the natural world, and they can be quite aggressive in expressing that dismissive attitude.

He concludes with the statement

> . . . we . . . need to recognize that there are both opportunities for engagement and obstacles of animosity and hostility on all sides of the

> scientific debates in our country. There are people—including some within the scientific community—who have no desire to bridge any scientific understanding gaps, and who hold the differing views of others in very low regard and with deep derision. And they may even hold our efforts at bridging in similar resentment as being appeasers or "accommodationists." This makes our role more complicated. We are not just communicating science on a landscape of open engagement and understanding; we must also mediate science on a landscape of open hostility and warring factions.

The documents on this web site are made available in this spirit.

Takeaway messages

The careful research described above indicates that

- 'Radiophobia' can inflict more harm on humans than the radiation exposure itself, depending on the situation. Its persistence is *not* due to simply public ignorance, but to ongoing affective reinforcement of a 'uniquely feared process'.
- Cancer risks for men professionally exposed to radiation are almost unrelated to the radiation dose: there is almost no effect.
- Genetic risks are much less than the risks of cancer, primarily because of biological repair mechanisms.
- Experts often perceive risks to be very much smaller than does the public. The differences in perception in controversial topics can be enormous.
- "Authorities can easily get a biased view of public opinion if they listen mostly to active groups, which are those most likely to voice their anxieties and get in touch with organizations responsible for risk management. This is an important reason for making surveys of the risk perception of the general public . . . "
- There are strong gender effects in risk perception: women tend to judge risks as higher than do men.

- The burden of communication is on scientists, to make clear not only the *significance* of their work but also the *process* by which they arrived at their conclusions.

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