Not Entirely Reliable: Private Scientific Organizations and Risk Regulation – The Case of Electromagnetic Fields

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Private scientific organizations exert a great deal of influence in the regulation of some technological risks. The high level of expertise of their members is arguably a good reason for them to participate in making and monitoring risk regulations, in order to adjust these to scientific progress. Nevertheless, there are also sound reasons why governments shouldn't uncritically follow the views expressed by such organizations. Taking the role played by the International Commission on Non-Ionizing Radiation Protection in the regulation of electromagnetic fields as an illustrative example, this paper shows that private scientific organizations such as these are structurally less well suited than democratic authorities when it comes to managing those risks.

I. Introduction

Electromagnetic radiation is a form of energy travelling through space in waves. It produces an electromagnetic field, which can be viewed as the combination of an electric field and a magnetic one, oscillating in phase perpendicular to each other and also perpendicular to the direction in which the wave propagates.

Electromagnetic radiation can be classified into ionizing and non-ionizing, according to whether it is capable of ionizing atoms and breaking chemical bonds. This paper focuses on the latter type.

Electromagnetic fields are ubiquitous. Some are naturally generated, for instance by the sun, the earth or even our own bodies. Others are artificially produced by household appliances, power lines, power transformers, electrical substations, mobile phones, etc.

During the 1970s and 1980s, various scientific studies were carried out in order to analyze how exposure to electromagnetic fields affects human health. We currently know that these fields can cause thermal and perhaps athermal effects. The former ones are well established and fully understood. They are caused by the overheating of the body when located in the direct radiation field. Most biological molecules absorb energy from electromagnetic fields, which is converted into kinetic energy, causing them to oscillate. This oscillation produces heat and an increase in body temperature. When the density of the energy absorbed exceeds a certain threshold, the resulting overheating can harm human health.[1]

As to non-thermal effects, by contrast, there is still a great deal of uncertainty. Several studies have suggested that exposure to low intensity electromagnetic fields, which do not produce heat, can however damage human health, e.g. increasing cancer risk. Nevertheless, no clear biological mechanism has been established that can explain these effects, while the majority view in the scientific community is that such evidence is not sufficiently serious or well substantiated enough to warrant the setting of safety thresholds with respect to athermal effects.[2]

Non-thermal effects started to raise public concern and countless disputes in the 1990s. Many citizens claimed before national courts that the electromagnetic radiation – usually generated by mobile phone masts, power transformers or high-voltage power

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1 See, e.g., Opinion of the Committee of the Regions on the Effects of high-voltage electricity transmission networks, OJ 1999 C 293/16, at p. 18.

2 *Ibid.*, at p. 18.

lines – to which they were exposed constituted a nuisance.[3]

In order to decide these cases, courts were initially confronted with great uncertainty, insofar as there were no legal rules setting maximum permissible exposure limits at the time and the scientific community had not dismissed the possibility that electromagnetic fields could produce harmful athermal effects. Many Courts based their decisions on non-binding rules made by non-governmental bodies, mainly on standards developed by organizations for standardization (e.g. *Deutsches Institut für Normung* and *Verband Deutscher Elektrotechniker*[4]) or on recommendations published by scientific bodies (e.g. International Commission on Non-Ionizing Radiation Protection).[5]

Most electric and mobile phone companies publicly undertook to comply with those rules, even though they were not mandatory. It should be noted, however, that those firms did not have to incur any extra costs in order to fulfil such commitments, as the intensity of the electromagnetic fields generated by their facilities was almost always already below the thresholds set down in the abovementioned documents.

Legislatures and governmental authorities stepped in afterwards laying down, *inter alia*, maximum permissible exposure limits. It was forbidden to exceed certain thresholds of electromagnetic radiation in areas where people – workers or members of the general public – could spend significant time. Moreover, almost all of the member States and candidate States of the European Union set down the same limits, those established by the Council in its Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), which in turn were identical to the limits proposed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in its 1998 Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz).[6] Only six of twenty five States deviated from these limits, setting down stricter ones,[7] and all of them took such Guidelines as the scientific basis and bench mark for their regulations.[8]

More than a decade later the question is whether governments should continue to rely on such experts and to toe the line that these latter have previously drawn. In fact, this is not exactly what has happened. There is indeed an increasing trend among European States to set lower limits than those proposed by the ICNIRP, there being arguably good reasons for this policy. In the present paper we suggest that private scientific organizations, such as the ICNIRP, are in a worse position than democratic governments when it comes to adapting some risk regulations to scientific progress, those organizations not being reliable enough in that regard.

II. Organization and functioning of the ICNIRP

In 1974, the Executive Council of the International Radiation Protection Association (IRPA), which is the international body representing radiation protection professionals world-wide, set up a Working

3 See, for example, Gabriel Doménech, "La contaminación electromagnética en el Derecho alemán", 220 *Revista de Derecho Urbanístico y Medio Ambiente* (2005), pp. 131 *et seq.*; Antonio E. Embid, *Precaución y Derecho. El caso de los campos electromagnéticos* (Madrid: Iustel, 2010), at pp. 333 *et seq.*

4 See, for the sake of illustration, *Verwaltungsgericht Koblenz* decision of 14 October 1986 (NVwZ 1987, pp. 149–150), *Verwaltungsgerichtshof Kassel* decisions of 13 March 1990 (2 R 3757/89) and 22 March 1993 (NVwZ 1994, pp. 391–395), *Oberverwaltungsgericht Lüneburg* decision of 21 April 1992 (NVwZ 1992, pp. 993–994), *Verwaltungsgericht Ansbach* decision of 29 September 1992 (CR 1994, 48–50), and *Verwaltungsgerichthof München* decisions of 15 September 1992 (14 CS 92.3208) and 25 October 1994 (NVwZ 1995, pp. 919–921).

5 See, for example, *Bundesverwaltungsgericht* decisions of 2 August 1994 (NVwZ 1994, pp. 1000–1002) and 9 February 1996 (DVBl 1996, pp. 682–684), *Verwaltungsgericht München* decisions of 27 January 1993 (NVwZ 1993, pp. 1121–1123), *Oberverwaltungsgericht Schleswig-Holstein* decisions of 22 February 1995 (4 M 113/94) and 29 August 1995 (BImSchG-Rsps. 22, 104), and *Verwaltungsgerichthof Manheim* decisions of 14 may 1996 (DÖV 1996, pp. 1005–1007), 2 January 1997 (NVwZ 1997, pp. 704–705) and 15 April 1997 (NVwZ 1998, pp. 416–418). The ICNIRP Guidelines had also been endorsed by the German Commission on Radiological Protection (*Strahlenschutzkommission*), whose recommendations in that regard were taken into account by those judicial decisions.

6 74 (4) *Health Physics* (1998), pp. 494–522.

7 See Implementation report on the Council Recommendation limiting the public exposure to electromagnetic fields (0 Hz to 300 GHz), 2002. Denmark, Finland, France, Germany, Ireland, Portugal, Spain, Sweden, Estonia, Latvia, Malta, Romania, Slovak Republic, Czech Republic, Republic of Lithuania, Poland and United Kingdom set down the same limits proposed by ICNIRP. In Belgium the exposure limits were set at one half of those recommended by ICNIRP. In Austria, the limits for the frequency range for GSM-Networks were slightly higher than those contained in the abovementioned guidelines. Switzerland applied these guidelines under normal conditions, but with stricter levels at "sensitive locations" and for mobile phone masts, only allowing 1 % of the levels of emission recommended by ICNIRP. Luxembourg also applied stricter limits for mobile phone base stations. Greece applied stricter limits for mobile phone masts, setting 80 % of those set down by ICNIRP. Slovenia established lower thresholds for almost all the frequencies. The aforementioned report did not provide detailed information on the limits laid down in the Netherlands and Italy.

8 *Ibid.*, at p. 51.

Group (one year later called Study Group) to review the health protection problems arising from non-ionizing radiations.

During the 4th International Congress of the IRPA, in 1977, the International Non-Ionizing Radiation Committee (ICNIRC) was created, which constituted the immediate forerunner of the ICNIRP.

The International Commission on Non-Ionizing Radiation Protection was founded by the General Assembly of the IRPA on 20 May 1992.[9] Its current Statutes were approved in 2008.[10]

The ICNIRP is a registered association under German Law and has its headquarters in Munich.[11] It describes itself as "an independent and neutral scientific commission, which writes its guidance and recommendations on the basis of established scientific principles only".[12] Its declared purpose is to "advance non-ionizing radiation protection for the benefit of people and the environment".[13] To pursue this goal, the ICNIRP intends to carry out the following activities:

"– analysing physical characteristics of NIR and reports of biological effects from exposure to NIR;
– recommending appropriate terminology, quantities, units and methods of measurement;
– developing protection criteria;
– recommending systems of protection against NIR, including appropriate exposure limits;
– giving guidance for the protection of workers, members of the public, patients and the environment;
– issuing statements, recommendations or papers on selected topics as appropriate, including reports on the application of Commission recommendations;
– collating and reporting of information and co-ordination of studies;
– initiating and participating in educational and research programs, and
– pursuing any other activities that allow the Commission to carry out its work".[14]

The ICNIRP consults widely with individual experts and organizations such as the European Union, the World Health Organization (WHO) and the International Labour Organization (ILO), collaborating with them in many research programs.[15]

The ICNIRP has an Executive Council (which in turn is made up of the Chairman, Vice-Chairman and Scientific Secretary) and additional members, at least five but not more than twelve.[16] Former members and other experts may be invited to participate in the scientific work of the Commission, but they do not have the right to vote.[17]

Members of the ICNIRP are elected and re-elected – in principle, for four years – by co-optation, i.e. by secret ballot and simple majority vote of the ICNIRP members.[18] The election has to be made with regard to their expertise and scientific independence, and geographical representation.[19] No one is eligible if retired at the time of election, and no member may hold a position of employment that in the opinion of the Commission will compromise its scientific independence.[20] In fact, almost all of them have similar backgrounds: some come from academia; others work in public research centres or in regulatory agencies.[21] The total duration of membership may not exceed three terms.[22]

It must be pointed out that the decisions of the ICNIRP have to be made by simple majority vote,[23] unless they relate to documents produced for publication, in which case they have to be adopted by consensus and, if this cannot be reached, by a three-quarters majority of the membership.[24]

9 See the Charter of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), approved by the General Assembly of the International Radiation Protection Association in Montreal, 20 May 1992, available on the Internet at <http://www.icnirp.de/documents/charter.pdf> (last accessed on 04 January 2013).

10 Statutes of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), approved at the Commission Meeting, 13–14 October 2008, in Rio de Janeiro, Brazil, available on the Internet at <http://www.icnirp.de/documents/statutes.pdf> (last accessed on 04 January 2013).

11 § 1 of ICNIRP Statutes, *supra* note 10.

12 Preamble of ICNIRP Statutes, *supra* note 10.

13 § 2.1 of ICNIRP Statutes, *supra* note 10.

14 § 4 of ICNIRP Statutes, *supra* note 10.

15 See, for example, <http://www.who.int/peh-emf/project/en/> (last accessed on 04 January 2013).

16 §§ 6.1 and 8.1 of ICNIRP Statutes, *supra* note 10.

17 §§ 6.7 and 9.10 of ICNIRP Statutes, *supra* note 10.

18 § 6.3 of ICNIRP Statutes, *supra* note 10.

19 § 6.3 of ICNIRP Statutes, *supra* note 10.

20 § 6.2 of ICNIRP Statutes, *supra* note 10.

21 For information on the background of ICNIRP members and consulting experts, see <http://www.icnirp.de/> (last accessed on 04 January 2013).

22 § 6.4 of ICNIRP Statutes, *supra* note 10.

23 § 9.6 of ICNIRP Statutes, *supra* note 10.

24 § 10.1 of ICNIRP Statutes, *supra* note 10.

III. The 1998 ICNIRP Guidelines

The ICNIRP has published several documents stating that exposure to electromagnetic fields should not exceed certain thresholds. The most influential of these documents have arguably been the 1998 Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz).[25]

These Guidelines establish two types of thresholds: "basic restrictions" and "reference levels". The former ones are restrictions – on exposure to electromagnetic fields – directly based on established health effects. The problem is that the physical quantities used to specify such restrictions are very difficult to measure. That is why reference levels are set down. They are specified in easier to measure physical quantities with the aim of determining whether the basic restrictions are likely to be exceeded. "Compliance with the reference level will ensure compliance with the relevant basic restriction". By contrast, if the measured or calculated value exceeds the reference level, it does not inevitably follow that the basic restriction will be exceeded, but a more detailed analysis is necessary in that regard.[26]

The ICNIRP claims that it has considered "only established effects (...) as the basis for the proposed exposure restrictions". And only short-term, immediate health effects are considered to be established. "In the case of potential long-term effects of exposure, such as an increased risk of cancer, ICNIRP concluded that available data are insufficient to provide a basis for setting exposure restrictions, although epidemiological research has provided suggestive, but unconvincing, evidence of an association between possible carcinogenic effects and exposure at levels of 50/60 Hz magnetic flux densities substantially lower than those recommended in these guidelines".[27]

In order to compensate for uncertainty as to exposure-effect threshold levels and adequately protect human health, safety factors (also called reduction factors) are introduced. Basic restrictions are calculated by dividing the limits for established effects by a factor which is ten for workers and fifty for the general public.[28] Nevertheless, the ICNIRP notes that, "there is insufficient information on the biological and health effects of EMF exposure of human populations and experimental animals to provide a rigorous basis for establishing safety factors over the whole frequency range and for all frequency modulations". In addition, the lack of knowledge concerning the appropriate dosimetry also produces uncertainty regarding the proper safety factor.[29]

The ICNIRP recognizes also that compliance with the Guidelines may not preclude interference with, or effects on, medical devices such as metallic prostheses, cardiac pacemakers and defibrillators, and cochlear implants. Furthermore, it points out that interference with pacemakers may occur at levels below the recommended reference thresholds.[30]

As said above, both the European Union and the overwhelming majority of its member and candidate States laid down the same exposure limits proposed by the 1998 ICNIRP Guidelines. And all of them took these Guidelines as the scientific basis and benchmark in order to regulate this controversial issue.

IV. Scientific progress and reaction of the ICNIRP: "you can look but you better not touch"

Since 1998, countless scientific studies on the effects of electromagnetic fields on human health have been published. Some of them have strengthened the hypothesis that levels of exposure to these fields at much lower than those laid down in the ICNIRP Guidelines can produce harmful non-thermal effects. A great deal of uncertainty, however, still surrounds the issue, because a lot of similar studies have not found any evidence of such effects and no causal mechanism has yet been discovered that can explain them.

The 1998 Guidelines are actually being revised and replaced step by step. With regard to the frequencies above 100 kHz, the ICNIRP considers that the scientific literature published since 1998 has provided no evidence of any adverse effects below the basic restrictions and does not demand an immediate revision of the exposure limits. The ICNIRP concedes that it is not possible to disprove the existence of non-thermal interactions, but in its opinion the plausibility of the biological mechanisms that have been proposed is very low and, moreover, the recent in-vitro and ani-

25 74 (4) *Health Physics* (1998), pp. 494–522.

26 *Ibid.*, at p. 495.

27 *Ibid.*, at p. 495.

28 *Ibid.*, at pp. 508 *et sqq.*

29 *Ibid.*, at p. 508.

30 *Ibid.*, at p. 495.

mal studies indicate that such effects are unlikely at low levels of exposure. Consequently, the ICNIRP "reconfirms the 1998 basic restrictions in the frequency range 100 kHz – 300 GHz until further notice".[31]

That is the conclusion even though some published studies have shown that the specific absorption rate (the rate at which energy is absorbed by the body when exposed to radiation) at the reference level recommended in the 1998 Guidelines could be up to 40 % higher than the current basic restrictions under worst case conditions. In the opinion of the ICNIRP, "this is negligible compared with the large reduction factor of 50 (5,000 %) for the general public".[32]

Regarding low frequencies, the ICNIRP has recently published the Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz),[33] in which no major change has been made. Compliance with them does not preclude interference or effects on medical devices.[34] Restrictions are still based only on established evidence regarding acute effects on human health.[35] Long term harmful effects have not been taken into account either, because it is the view of the ICNIRP that the currently existing scientific evidence that prolonged exposure to low frequency magnetic fields is causally related with these effects is too weak to form the basis for exposure guidelines.[36] The following examples can serve to illustrate this opinion.

Some people claim to be hypersensitive to electromagnetic fields, but the ICNIRP points out that double-blind provocation studies suggest that reported symptoms are unrelated to exposure to such fields.[37]

There is also only inconsistent and inconclusive evidence that exposure to low-frequency electric and magnetic fields causes depressive symptoms or suicide.[38]

Some reports suggest that people employed in electrical occupations might have an increased risk of amyotrophic lateral sclerosis. But no biological mechanism has been established which can explain this association, which could have arisen because of confounders related to electrical occupations. In addition, more sophisticated studies have generally not observed increased risks.[39]

Associations with Alzheimer's disease have been found both in clinic based studies with a large potential for selection bias and in population based studies. In the opinion of the ICNIRP, nonetheless, these studies are inconsistent because of several reasons: probable publication bias, control of potential confounding from other occupational exposures, etc.[40]

Though various cardiovascular changes have been reported in literature, the majority of effects are small, and the results have not been consistent within or between studies. Furthermore, most of the studies of cardiovascular disease morbidity and mortality have shown no association with exposure to electromagnetic fields.[41]

There is some evidence for increased risk of miscarriage associated with maternal magnetic field exposure, but this association has not been found in other studies and overall the evidence for such an association is limited and poor.[42]

A considerable number of epidemiological reports, carried out during the 1980's and 90's, indicated that long term exposure to 50–60 Hz magnetic fields (those created, *inter alia*, by high voltage power lines and transformers), orders of magnitude below the thresholds set down in the 1998 ICNIRP Guidelines might be associated with cancer. Several similar studies published after 1998 have strengthened this hypothesis, suggesting that long term exposure to residential magnetic fields whose intensity (0.3 to 0.4 microT) was hundred times lower than that established by the ICNIRP Guidelines (100 microT) substantially increases (e.g. doubling) childhood leukemia risk.[43] Other studies have also shown poorer

31 ICNIRP Statement on the "Guidelines for limiting exposure to Time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)", 97:3 *Health Physics* (2009), pp. 257–258, at p. 257.

32 *Ibid.*, at p. 257.

33 99:6 *Health Physics* (2010), pp. 818–836.

34 *Ibid.*, at p. 818.

35 *Ibid.*, at p. 818.

36 *Ibid.*, at p. 824.

37 *Ibid.*, at p. 821.

38 *Ibid.*, at p. 821.

39 *Ibid.*, at p. 822.

40 *Ibid.*, at p. 822.

41 *Ibid.*, at p. 822.

42 *Ibid.*, at p. 822.

43 A. Ahlbom, N. Day, M. Feychting et al., "A pooled analysis of magnetic fields and childhood leukaemia", 83 *British Journal of Cancer* (2000), pp. 692 *et seq.*; Sander Greenland, Asher R. Sheppard, William T. Kaune et al., "A pooled analysis of magnetic fields, wire codes, and childhood leukemia", 11 *Epidemiology* (2000), pp. 624 *et seq.*; Carlotta Malagoli, Sara Fabbi, Sergio Teggi et al., "Risk of hematological malignancies associated with magnetic fields exposure from power lines: a case-control study in two municipalities of northern Italy", 9:16 *Environmental Health* (2010), pp. 1 *et seq.*; Gerald Draper, Tim Vincent, Mary E. Kroll et al., "Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study", 330 *British Medical Journal* (4 June 2005), pp. 1 *et seq.*

survival among children with leukemia who were exposed to magnetic fields above 0.3 microT.[44] In 2002, the accumulation of evidence led the International Agency for Research on Cancer to classify magnetic fields as a "possible human carcinogen".

In the opinion of the ICNIRP, nevertheless, the results of those studies could be explained by a "combination of selection bias, some degree of confounding and chance". It stresses that no biophysical mechanism has been identified and the experimental results from animal and cellular laboratory studies do not support the notion that exposure to such fields is a cause of childhood leukaemia.[45] And it states as well that, "the absence of established causality means that this effect cannot be addressed in the basic restrictions".[46]

Yet the ICNIRP considers that basic restrictions should be modified for two reasons. First, the 2010 basic restrictions are grounded on induced internal electric fields, as this is the physical quantity that directly determines the biological effect. The 1998 Guidelines, on the contrary, were based on another metric as were most experimental data at the time. Now, sufficient information on the new metric is available to be used in the guidelines.[47] The second reason is to avoid the induction of retinal phosphenes and prevent any possible effects on brain function, because they may be disturbing in some circumstances, although not harmful to human health.[48]

Reference levels have also changed as a consequence of the revised basic restrictions and the progress in dosimetry. The 2010 Guidelines use more sophisticated and realistic models to estimate induced currents in the human body.[49] As a result, the new reference levels for magnetic fields tend to be less conservative than the previous ones, whereas the electric field reference levels remain, with some exceptions, basically unchanged. It must be noted, for example, that the limit for magnetic fields of 50 Hz (the power frequency) has been doubled up to 200 microT. This result is questionable to say the least, given that several epidemiological studies have "consistently found"[50] that long term exposure to 50 Hz magnetic fields of much lower intensity (0.3–0.4 microT) is associated with a substantial increase of childhood leukaemia risk.

V. The governmental reaction: Tendency to lay down stricter limits

Broadly speaking, the reaction of European Governments has been different. There is indeed an increasing trend to reduce the limits of maximum permissible exposure to electromagnetic radiation. In 2008, eleven of the twenty eight considered States had set down lower thresholds – in some cases, thousand times lower – than those recommended in the 1998 ICNIRP Guidelines.[51] Most European States, however, still continue to observe the same recommended restrictions.

VI. Are private scientific organizations better placed than governments in order to adjust risk regulations in the light of scientific progress?

1. The advantage of knowledge

Members of private scientific organizations, such as the ICNIRP, are presumably well positioned to continually observe and understand the scientific progress with the aim of adjusting risk regulations to it. This advantage is arguably a good reason for these organizations to somehow participate in making and monitoring such regulations.

44 D. E. Foliart, B.H. Pollock, G. Mezei et al., "Magnetic field exposure and long-term survival among children with leukaemia", 94 *British Journal of Cancer* (2006), pp. 161 *et seq.*; Anne L. Svendsen, T. Weihkopf, P. Kaatsch et al., "Exposure to magnetic fields and survival after diagnosis of childhood leukemia: a German cohort study", 16:6 *Cancer Epidemiology, Biomarkers & Prevention* (2007), pp. 1167 *et seq.*

45 99:6 *Health Physics* (2010), at p. 823.

46 *Ibid.*, at p. 830.

47 *Ibid.*, at pp. 825 *et seq.*

48 *Ibid.*, at p. 825.

49 *Ibid.*, at p. 824.

50 *Ibid.*, at p. 830.

51 See Report from the Commission on the application of Council Recommendation of 12 July 1999 (1999/519/EC) on the limitation of the exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Second Implementation Report 2002–2007, 1.9.2008, COM(2008)532 final. Spain is to be included in this list of 11 European States. Although the exposure limits provided for in the Royal Decree 1066/2001, of 28 September, are exactly the same than those proposed by the 1998 ICNIRP Guidelines, many Spanish Regions and Municipalities have established lower thresholds. For more details, see Embid, *Precaución y Derecho*, *supra* note 3, at pp. 448 *et seq.*

2. Risk of partiality

Both authorities and scientists can be involved in a conflict of interest or/and be exposed to the pressure from interest groups. These circumstances can exert an undesirable influence on their assessments, judgments, recommendations and decisions, undermining their impartiality and objectivity.

It may be claimed that such risk of partiality is higher for private scientists than for democratically elected decision-makers. The main reason for this is that authorities elected by universal, free and equal suffrage will probably tend – at least to some extent – to make decisions meeting the interests of most voters, if they aim to be re-elected and remain in power.

Democratic elections assure to some degree that governments will serve the interests of the majority of the population. By aligning the personal interest of elected officials in staying in power with that of most citizens, such election system increases the probability that the former will be sensitive to the changing demands of the latter ones. In a democracy, politicians who egoistically seek to maximize their own goals will have to meet the needs of a broad group of people.

Members of private scientific organizations, by contrast, are not usually elected by universal, free and equal suffrage. Those of the ICNIRP, for example, are co-opted. In this way one mechanism that guarantees to some degree that their assessments and recommendations will tend to satisfy the demands of at least the majority of citizens disappears. In the absence of such a guarantee, the probability that their own interests conflict with those of the majority of voters increases.

One can thus suspect that the best experts in some risk technology – e.g. genetic engineering or nanotechnology –, who may derive substantial revenues and prestige through this expertise, do not have the right incentives, from a social point of view, to objectively assess the risks and benefits of both this technology and its alternatives. It is in their own interest to give opinions that stress the pros and understate or even conceal the cons.

One may also expect that scientists who obtain monetary or reputational benefits from some interests groups will tend to give opinions and recommendations biased in favour of these groups. And there are many ways in which such groups can directly or indirectly provide incentives to experts: funding research programs, recruiting them to write *amicus curiae* briefs or to participate in public debate, etc. And the most renowned experts are usually able to return favours exerting influence on legislators, courts and the public in multiple ways: not only participating in the works of organizations such as the ICNIRP, but also publishing scientific papers, writing reports designed for use in regulatory settings, writing amicus briefs, acting as expert witnesses, providing support to parties involved in litigation, publishing popular overviews of the debate, etc.[52]

3. Lack of accountability and transparency

There are multiple mechanisms through which democratically elected officials have to give account of their decisions, stating the reasons on which such decisions are based. These officials are accountable to Parliament, to courts, to citizens, etc. Moreover, democratic authorities have to ensure the public's access to the information held by them, especially on environmental issues.[53]

Accountability and transparency serve important goals. They enable citizens to monitor the performance of public agents, thereby reducing the risk of these latter misusing their power or making decisions contrary to the interests of the former. They prevent misbehaviour by increasing the probability of such actions being detected and the responsible individuals being "punished" in one way or another. As Justice Brandeis famously wrote, "Sunlight is said to be the best of disinfectants; electric light the most efficient policeman".[54] Not surprisingly, some empirical studies have shown that transparency of risk management procedures enhances the trust of citizens in the resulting decisions.[55] Those are among the main reasons why such procedures have become arguably more transparent over the

52 See David Mercer, "Weighty Knowledge: Hyper Expertise and the Vertical Integration of Expertise (HEVIE)", *Yearbook 2006 of the Institute for Advanced Studies on Science, Technology and Society*, pp. 337 *et seq*.

53 See European Parliament and Council Directive 2003/4/EC on public access to environmental information and repealing Council Directive 90/313/EEC, OJ 2003 L 41/26.

54 See Louis D. Brandeis, *Other People's Money. And How the Bankers Use It* (New York: Frederick A. Stokes Company, 1914), at p. 92.

55 Paul Slovic et. al., *The Perception of Risk* (London: Earthscan, 2000), at p. 321.

years,[56] although there is still plenty of room for improvement.[57]

Private scientific organizations such as the ICNIRP, on the contrary, are not accountable to anybody. They can give reasons for their decisions, but they do not need to do so. They usually publish some documents, but it is not mandatory for them to do so. They disclose only the information they want to disclose. Furthermore, their decision-making processes are not as transparent as those of democratic organizations. This lack of accountability and transparency increases the risk of bad decisions being made.

4. Lack of plurality

Plurality of points of view is of great importance in order to obtain and properly assess the information that will form the basis to make risky decisions, as it is in the setting of limits of maximum permissible exposure to electromagnetic fields.

Diversity of perspectives is a *conditio sine qua non* of dialogue and criticism, which are necessary in order to detect many mistakes, inconsistencies and prejudices. These latter, as Feyerabend noted, "are found by contrast, not by analysis". "Usually, we are not even aware of them and we recognize their effects only when we encounter an entirely different cosmology".[58]

The fact that people with different points of view and disparate or even strongly contradictory positions take part in a deliberation facilitates exchange of ideas, transparency, better knowledge of both the considered alternatives and the reasons therefore, criticisms, formulation of new alternatives and argumentative effort. In addition, the heterogeneity of actors tends to neutralize their possible biases and lack of impartiality. "Collective decision making is most likely to amplify bias when it is *homogeneous* across participants. Heterogeneous biases create the potential for bias correction through constructive conflict".[59]

The homogeneity of the participants in discussion reduces the quantity and the quality of the information on which judgment should be based, and tends to stifle critical dialogue, to reinforce any common points of view and biases, and to produce extreme outcomes, polarized in the direction of such points of view and biases.[60]

Private scientific organizations are often notably homogeneous. This is clearly the case of the INIRP. All its members have similar backgrounds. All of them match the profile of professional scientists working for universities, public research centres or administrative agencies. Alternative or critical views are absent, such as, for instance, those of the firms that produce the most controversial electromagnetic fields and, above all, those of the people exposed to them, whose ability to directly or indirectly influence the current members of the ICNIRP is usually much more limited.

This lack of plurality is not fortuitous at all, but caused by the system used to elect the members of the INCIPR. As everybody knows, cooptation tends to produce homogeneous, conservative, immobile and not sufficiently innovative groups.

This stands in sharp contrast with the principles underlying current European Union Law. As stated in the Communication from the Commission on the collection and use of expertise, pluralism is a determinant of the quality of the scientific advice. Therefore, "wherever possible, a diversity of viewpoints should be assembled. This diversity may result from differences in scientific approach, different types of expertise, different institutional affiliations, or contrasting opinions over the fundamental assumptions underlying the issue. Depending on the issue and the stage in the policy cycle, pluralism also entails taking account of multi-disciplinary and multi-sectorial expertise, minority and non-conformist views. Other factors may also be important, such as geographical, cultural and gender perspectives".[61] According to the Commission, "departments should cast their nets as widely as possible in seeking appropriate expertise. As far as possible, fresh ideas and insight should be sought by including individuals outside the

56 See, for instance, Gabriel Doménech, "New European Legislation on Pharmacovigilance", 13 *Pharmaceuticals Policy and Law* (2011), at pp. 17 *et seq*.

57 See, for instance, Elizabeth Fisher, "Drowning by Numbers: Standard Setting in Risk Regulation and the Pursuit of Accountable Public Administration", 20:1 *Oxford Journal of Legal Studies* (2000), pp. 109–130.

58 Paul K. Feyerabend, *Against Method*, 3rd ed. (London: Verso, 1993), at p. 22.

59 Robert J. MacCoun, "Biases in the Interpretation and Use of Research Results", 49 *Annual Review of Psychology* (1998), at p. 279.

60 See Cass Sunstein, "Deliberative Trouble? Why Groups Go to Extremes", 110 *Yale Law Journal* (2000), pp. 71 *et seq*.

61 Communication from the Commission on the collection and use of expertise by the Commission: Principles and guidelines. "Improving the knowledge base for better policies", of 11 December 2002, COM(2002) 713 final, at p. 9.

department's habitual circle of contacts. Departments should also strive to ensure that groups are composed of at least 40 % of each sex". "Both mainstream and divergent views should be considered".[62]

This principle of pluralism has been consequently enshrined in many European legal provisions. The appointment of the members of the body responsible for providing scientific assessment and recommendations to European authorities on any concerns relating to post-marketing surveillance of medicines (Pharmacovigilance Risk Assessment Committee) can serve as an example to illustrate this point. Each member state appoints one member and one alternate. Another six members are appointed by the Commission of the European Union, on the basis of a public call for expressions of interest, with the aim of ensuring that the relevant expertise is available within the Committee. One member and one alternate are appointed by the Commission, on the basis of a public call for expressions of interest, after consulting the European Parliament, in order to represent healthcare professionals. One member and one alternate are appointed by the Commission, through the procedure just mentioned, for the purpose of representing patient organizations.[63] The European legislator has also established that all members and alternates of the Committee have to be appointed on the basis of their relevant expertise in pharmacovigilance matters and risk assessment of medicines for human use, in order to guarantee, *inter alia*, a broad spectrum of relevant expertise. For this purpose, member States shall liaise with European authorities in order to ensure that the final composition of the Committee covers all the scientific areas relevant to its tasks.[64]

It must be noted thus that, in addition to having stated that the composition of the Committee has to be plural, the European legislator has established several guarantees to effectively achieve this goal: a) it has distributed the power to appoint the members of the Committee among the European Commission and the twenty seven states of the European Union, which may have different interests and points of view on the matter; b) some members are appointed through a public and open procedure, which promotes the objectivity of the election and the possibility of integrate new and plural perspectives into the Committee; c) the involvement of the European Parliament in this procedure guarantees to some extent the protection of the interests represented by this institution; d) the inclusion of representatives of healthcare professionals and patient organizations facilitates their points of view being taken into account in assessing the risks relating to medicines.

5. Cognitive biases

It is well established that people usually suffer from cognitive biases, which can distort their perception and lead them to systematically make certain mistakes in assessing risks. And some of these biases can constitute, to a greater o lesser degree, an impediment for governments and experts to adjust risk regulations to scientific and technological progress.[65]

a) Anchoring

Individuals often use an anchoring and adjustment heuristic in order to assess probabilities. They start from an initial value and then adjust it to yield the final estimate. The starting point may be the result of a partial computation or even suggested by the way the problem is framed. In either case, adjustments are typically insufficient. Final estimates are therefore overly influenced by the initial values, biased toward these latter ones, excessively close to them. This phenomenon is called anchoring.[66]

It is conceivable that such bias can exert a negative influence on the setting of limits of maximum permissible exposure – e.g.to electromagnetic radiation – at least in two moments. Firstly, when determining safety factors for the purpose of compensating uncertainty as to exposure levels above which harmful effects are to be expected. Anchoring could cause these

62 *Ibid.*, at pp. 11–12.

63 Art. 61a.1 of Regulation (EC) No 726/2004 of the European Parliament and of the Council laying down Community procedures for the authorisation and supervision of medicinal products for human and veterinary use and establishing a European Medicines Agency, as amended by Regulation (EU) No 1235/2010 of the European Parliament and of the Council, OJ 2010 L 348/1.

64 *Ibid.*, art. 61b.3.

65 Scientists and public authorities suffer from other biases as well, but we are not going to consider them here, insofar as they are not particularly relevant for those individuals to properly to adjust such regulations. See, for example, MacCoun, "Biases", *supra* note 59, at pp. 259 *et seq*.

66 See, e.g., Amos Tversky & Daniel Kanehman, "Judgment under uncertainty: Heuristics and biases", 185 *Science* (27 September 1974), pp. 1124–1131; Dan Ariely, George Loewenstein & Drazen Prelec, "'Coherent Arbitrariness': Stable Demand Curves without Stable Preferences", 118 *Quarterly Journal of Economics* (2003), pp. 73–105.

reduction factors to be too low and, consequently, the final limits to be too high in order to adequately protect human health.

Secondly, anchoring might affect the revision and updating of the exposure limits, i.e. their adjustment to the scientific and technological progress. It could lead the new limits to be too close to the initial ones. Suppose, for instance, that after limits of exposure to electromagnetic fields has been laid down then several scientific studies establish that exposure to electromagnetic fields below those limits can harm human health. Anchoring bias could cause the subsequent reduction of the limits to be insufficient.

Anchoring affects both experts and laymen. And there is no evidence the latter are affected to a greater degree than the former ones, or *vice versa*.[67] It seems hence that private scientific organizations do not have an advantage over governments in this respect.

b) *Status quo* bias

In almost every decision problem there is an alternative consisting of keeping things as they are, i.e. not changing the current state of affairs. It has been empirically well established that, in some circumstances, people have an overly tendency to choose this option, namely to reiterate the decisions made previously and not to change their preceding behaviour.[68] This *status quo* bias is closely related to other psychological phenomena, especially to omission bias, i.e. to the people's tendency to do nothing when facing a problem or, in other words, to prefer options that do not require action on their part. These two biases are independent of each other. They may well occur for the same reasons, and usually work in concert, insofar as actions often cause a change in the state of the world, but not always. Preservation of *status quo* sometimes requires an action.[69] But this does not always happen.

There may be good, rational reasons for preferring the *status quo* (e.g. avoiding the costs of the actions required to change the current world). Several scientific studies suggest, nonetheless, that there are also irrational sources of this preference. Emotions such as regret and fear play an important role. On the one hand, people try to minimize negative emotions – and, of course, maximize positive ones – that the outcomes of their decisions could cause for them in the future. On the other hand, they do the same with respect to the emotions they experience at the time of deciding. Thus, people tend to maintain the *status quo* insofar as deviating from it generates, both during the decision process and afterwards, worse emotions than preserving it.[70]

The more arduous the decision, the more intense the aroused emotions will be and the more the tendency towards maintaining the *status quo* will be accentuated. Difficulty of decisions depends on several factors: the strategy employed to decide – compensatory approaches, where the decision maker trades off the value of one attribute on one option with a value of another attribute within or across options, imply more difficulties than non-compensatory ones, where trade-offs are not made –; the number of relevant reasons for making a decision; the uncertainty surrounding the decision; the degree of structure and definition of the problem; the overall attractiveness of the options available to the decision maker; the presence of conflicting values; the number of options available, etc.[71]

Anticipated regret – the regret decision-makers think they could feel after deciding – and anticipated blame – the blame they think might be attributed to them by others for wrongdoing – play also an important role. Both of them depend in turn on several factors: reversibility of the decision; ease of constructing counterfactual alternatives to its outcome; expectation of feedback regarding the outcome of foregone options; degree of loss aversion; perceived responsibility for the outcomes; availability and abnormality of the action option, etc.[72]

Status quo inertia has been found in many fields, including politics and science.[73] But there is no evi-

67 See, e.g., Gregory B. Northcraft-Neale & Margaret A. Neale, "Experts, Amateurs, and Real Estate: An Anchoring-and-Adjustment Perspective on Property Pricing Decisions", 39 *Organizational Behavior and Human Decision Processes* (1987), pp. 84–97; Birte Englich, "Blind or Biased? Justitia's Susceptibility to Anchoring Effects in the Courtroom Based on Given Numerical Representations", 28:4 *Law and Policy* (2006), pp. 495 *et seq.*

68 See William Samuelson and Richard Zeckhauser, "Status Quo Bias in Decision Making", 1:7 *Journal of Risk and Uncertainty* (1988), pp. 7–59.

69 See Christopher J. Anderson, "The Psychology of Doing Nothing: Forms of Decision Avoidance Result From Reason and Emotion", 129:1 *Psychological Bulletin* (2003), pp. 139 *et seq.*

70 *Ibid.*, at pp. 141 *et seq.*

71 *Ibid.*, at pp. 154 *et seq.*

72 *Ibid.*, at pp. 148 *et seq.*

73 See Samuelson & Zeckhauser, "Status quo Bias", *supra* note 68, at pp. 41 *et seq.*

dence suggesting politicians suffer from it to a greater degree than scientists, or *vice versa*.

c) Confirmation bias

This term describes the fact that people tend to seek and use evidence in ways that confirm their pre-existing beliefs, expectations or hypothesis. It is indeed well established that individuals have a tendency: to search for information, empirical data and reasons that support their current positions and, conversely, to not seek or even to avoid evidence that would be considered contrary to them and supportive of alternative possibilities; to remember more easily the information that reinforces those beliefs; and to interpret new data according to them ignoring, disregarding, discrediting, dismissing or rationalizing contrary evidence. It may happen that individuals reinforce their opinions even though the new evidence is opposed to them.[74]

Confirmation bias is closely related to cognitive consistency, i.e. the tendency of individuals to maintain their attitudes, beliefs and views despite confirming information. There is not yet a well established explanation on what causes such phenomenon. Several theories have been proposed in that regard: people have an inclination to disbelieve, neglect or rationalize dissonant information in order to reduce the discomfort they experience when simultaneously holding conflicting ideas; inconsistency is perceived as a negative trait and, consequently, individuals try to avoid it for the purpose of not being negatively evaluated by others, etc. What has been better established is that some factors are positively correlated with that tendency, such as public expression of the considered beliefs, public commitment to them, and the generation of explanations or reasons supporting those beliefs.[75] It must be noted, by the way, that all of these factors have been present in the case of the 1998 ICNIRP Guidelines.

Scientists are not immune to confirmation bias. One could argue that they are better trained and more prone to challenge their conjectures than laymen. But it must be underlined that the characteristic critical attitude of the former, which has been so important for the progress of humankind, is hardly used against their own opinions, but usually the ones held by other people. Scientists rarely make criticism of their own theories or try to seek information in order to prove how wrong they are. Their criticisms are normally directed against the ideas of other scientists. It is more probable that they search for evidence that could confirm their own theories rather than refute them.[76]

Nevertheless, there is no evidence that confirmation bias affects scientists to a lesser or a greater degree than laymen or governmental authorities.

d) Overconfidence

This term describes the inclination of individuals to overestimate their own performances (overestimation), to mistakenly believe these performances are better than those of others (overplacement) and to have too much confidence in the truth or accuracy of their judgements (overprecision).[77] They are excessively optimistic so to speak.

It is empirically well established that also experts suffer from this bias.[78] And there is evidence that they are, in some circumstances, even more overcon-

74 Raymond S. Nickerson, "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises", 2:2 *Review of General Psychology* (1999), pp. 175–220.

75 See Stephanie Stern, "Cognitive Consistency: Theory Maintenance and Administrative Rulemaking", 63 *University of Pittsburgh Law Review* (2002), pp. 602 *et seq.* (analyzing how cognitive consistency may cause agencies to prematurely commit –"lock in"– to a proposal and thus undermine the value of public participation in administrative rulemaking; and suggesting some remedies).

76 See, for instance, Michael J. Mahoney, "Publication prejudices: An experimental study of confirmatory bias in the peer review system", 1:2 *Cognitive Therapy and Research* (1977), pp. 161–175; Clifford R. Maynatt et al., "Confirmation bias in a simulated research environment: An experimental study of scientific inference", 29:1 *Quarterly Journal of Experimental Psychology* (1977), pp. 85–95; Jonathan J. Koehler, "The Influence of Prior Beliefs on Scientific Judgments of Evidence Quality", 56:1 *Organizational Behavior and Human Decision Processes* (1993), pp. 28–55.

77 See Dale Griffin & Amos Tversky, "The Weighing of Evidence and the Determinants of Confidence", 24 *Cognitive Psychology* (1992), pp. 411 *et seq.*; Lyle A. Brenner et al., "Overconfidence in Probability and Frequency Judgments: A Critical Examination", 65:3 *Organizational Behavior and Human Decision Processes* (1996), pp. 212 *et seq.*; Joshua Klayman et al., "Overconfidence: It Depends on How, What, and Whom You Ask", 79:3 *Organizational Behavior and Human Decision Processes* (1999), pp. 216 *et seq.*

78 See, for instance, Stuart Oskamp, "Overconfidence in case-study judgments", 29:3 *Journal of Consulting Psychology* (1965), pp. 261 *et seq.*; Fergus Bolger & George Wright, "Reliability and validity in expert judgment", in Fergus Bolger & George Wright (eds.), *Expertise and decision support* (New York: Plenum Press, 1992), pp. 50 *et seq.*; Tadeusz Tyszka & Piotr Zielonka, "Expert Judgments: Financial Analysts versus Weather Forecasters", 3:3 *Journal of Psychology and Financial Markets* (2002), pp. 152 *et seq.*; Gunther Tichy, "The over-optimism among experts in assessment and foresight", 71 *Technological Forecasting & Social Change* (2004), pp. 341 *et seq.* (noting, *inter alia*, that the degree of overconfidence is positively correlated with the degree of self-rated knowledge); Shi-Woei Lin & Vicky M. Bier, "A study of expert overconfidence", 93 *Reliability Engineering and System Safety* (2008), pp. 711 *et seq.*

fident than laypeople,[79] particularly when predictability is very low. Some psychologists have indeed claimed that overconfidence is most pronounced when the strength (or extremeness) of the evidence that forms the basis of a judgment is high and the weight (or credence or predictive validity) of such evidence is low.[80] When predictability is high, experts are generally better calibrated than laypeople. By contrast, when predictability is very low (i.e. the quality of the available data is too poor to make reliable judgments), then experts, who usually have rich models of the considered fields, are more prone to overconfidence than laymen, who have a very limited understanding of these fields.[81] Given the great deal of uncertainty still surrounding non-thermal effects of electromagnetic radiation, one can arguably assume that this is a domain where experts may probably exhibit more overconfidence than politicians.

Some studies indicate that isolation and homogeneity of a social group might favour overconfidence. It has indeed been found that greater overconfidence is associated with more "constrained" social networks, i.e. groups with many strong interconnections and weak connections to outsiders. Such social environments are propitious for forming shared beliefs because, "they provide many opportunities for members to tell one another that they are right and few opportunities for prevailing ideas to be challenged".[82]

It has also found that expert opinions are often positively correlated, which can mask and exacerbate overconfidence.[83] And one can reasonably assume that, if the considered judgment is made by a group of experts, their homogeneity will tend to increase such positive correlation. Given that, it is not surprising at all that it has been claimed that expert's assessment should be conducted by panels composed by a, "fair mixture of experts of different grades with different types of knowledge and affiliation, and not only on top specialists of the respective field".[84]

The consequences of overconfidence should not be underestimated. It could lead decision makers to take excessive risks and to fail to gather additional information in order to reduce uncertainty and make better decisions.[85] In particular, it could exacerbate the effects of both the confirmatory and the *status quo* bias. If one is too confident in the accuracy of his or her beliefs, he or she will probably tend to not revise and update them as much as he or she should. From my personal experience, I would say that scientists hardly ever abandon their own scientific theories and beliefs, and certainly not as often as politicians, who usually have few scruples in saying one thing today and the opposite tomorrow.

6. Elasticity of scientific theories and elasticity of regulations

Science moves discontinuously. History has taught us that scientific paradigms are not modified and even less abandoned in response of whatever contrary evidence, but only when the anomalous results reach some critical point and a new paradigm, which can explain these results better, become accepted by the scientific community. Scientific theories are not automatically discarded at the first setback, just after new empirical data have apparently refuted them. Change does happen only when contradictions and anomalies are serious enough, when the accumulated contrary evidence reaches a certain level of quantity and quality.[86] Scientific theories thus are, to some degree, resistant to change.

The procedure the ICNIRP follows in order to produce documents for publication illustrates well this conservative bias characteristic of scientists. Let us remember that such decisions have to be adopted by consensus and, if this cannot be reached, by a three-quarters majority of the membership.[87] This rule obviously favours the preservation of the *status quo*, for a minority of a quarter of the ICNIRP members

79 Griffin & Tversky, "The Weighing of Evidence", *supra* note 77, at p. 430; Paul Slovic et al., *The Perception of Risk* (London: Earthscan, 2000), at pp. 209–210; Gustaf Törngren & Henry Montgomery, "Worse than chance? Performance and Confidence Among Professionals and Laypeople in the Stock Market", 5:3 *Journal of Behavioral Finance* (2004), pp. 148 *et seq.*; Tomasz Zaleskiewicz, "Financial forecasts during the crisis: Were experts more accurate than laypeople?", 32 *Journal of Economic Psychology* (2010), pp. 384 *et seq.*

80 Griffin & Tversky, "The Weighing of Evidence", *supra* note 77, at pp. 412 *et seq.*

81 *Ibid.*, at p. 430.

82 See Klayman et al., "Overconfidence", *supra* note 77, at p. 243.

83 See Vicki Bier, "Implications of the Research on Expert Overconfidence and Dependence", 85 *Reliability Engineering and System Safety* (2004), pp. 321 *et seq.*, at pp. 324–325.

84 Tichy, "The over-optimism", *supra* note 78, at p. 360.

85 Bier, "Implications", *supra* note 83, at pp. 324–325.

86 See Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962); Imre Lakatos, *The Methodology of Scientific Research Programmes* (Cambridge: Cambridge University Press, 1978).

87 § 10.1 of ICNIRP Statutes, *supra* note 10.

can block any change in the statements and recommendations made by this organization.

There are, of course, several factors that could also explain to some extent this inelasticity of science, even though they do not justify it from the social welfare point of view. It must be noted, for instance, that the oldest and most renowned experts in a certain theory, who usually are also the most influential ones in that regard, have few economic incentives to refute or abandon it insofar as this would imply a devaluation of the knowledge and the services they could offer in the science market.

Such conservative bias could be reasonable, at least partially, from a scientific perspective. A certain degree of resistance to change is probably necessary to bring here some stability that enables scientists to avoid accepting and discarding scientific theories prematurely, before they have been properly tested. It assures they will be subjected to strict scrutiny. It encourages people interested in defending or refuting a theory to search for evidence in order to verify or falsify it.

But this does not mean that such degree of inelasticity, justified as it may be in the scientific arena, has to be inexorably plausible in the realm of policy and law as well, not even when legislatures, administrative agencies or courts should base their decisions on the best and most recent scientific knowledge.

The publication of empirical studies that suggest that a product or activity is more dangerous for human health than has been considered according to a "well established" scientific theory, for example, may perhaps not be a sufficient reason to discard this theory, but it may be a very sound justification for amending the regulation of such product or activity in order to adequately protect people.

Paradoxical as it may sound, the degree of discontinuity (stability, elasticity or resistance to change) of scientific theories does not necessarily have to be equal to that of the regulations based on those theories. The reason is quite simple: the social costs – e.g. for human health – of maintaining unaltered such regulations can be notably different from the social costs – e.g. for the scientific progress – of provisionally maintaining those theories[88] at the purely scientific level. Moreover, one can reasonably argue that the former are usually higher than the latter ones, in particular when the interests at stake are of great importance. If that is the case, the legal rules in question should change in response to new evidence more elastically than the underlying scientific theories.

The limits of maximum permissible exposure to electromagnetic fields proposed by the ICNIRP, however, have not taken into account this crucial difference between law and science, between legal rules and scientific theories. The ICNIRP considers that there is no ground to substantially reduce the thresholds set down in its 1998 Guidelines, for the empirical evidence that has come to light since then is not consistent enough to discard the "traditional" scientific theory on the non-thermal effects of electromagnetic radiation. That organization implicitly assumes that the responsiveness-to-new-information of the scientific theories on the health effects of electromagnetic fields has to be the same than the responsiveness-to-new-information of the legal rules laying down exposure limits in order to protect people. This is an incorrect assumption. An slight increase of the plausibility of the minority scientific view according to which electromagnetic fields far below the thresholds set by the 1998 ICNIRP Guidelines can cause harmful health effects might perhaps not be a reason enough to abandon the opposite, mainstream view. This is certainly a problem to be solved by scientists according to the criteria commonly accepted among the scientific community.

But that same increase may also justify and even require that such thresholds be reduced if the social benefits – e.g. for human health – of the reduction exceed its social costs. And this is a question government, not scientists, should solve in accordance with the rules and principles of the law.

VII. Conclusion

There are several good reasons for governments not to uncritically follow the recommendations made by private scientific organisations such as the ICNIRP in order to regulate some risks, in particular those risks that affect third parties.

Such organisations do not have the right incentives to make the decisions – or, eventually, the recommen-

88 On the question of whether a mere change in the consensus within the scientific community concerning the efficacy of a medicinal product, which is not based on any new data, can on their own justify the withdrawal of the marketing authorisation of such product, see joined Cases T-74/00, T-76/00, T-83/00 to T-85/00, T-132/00, T-137/00 and T-141/00, *Artegodan and others v. Commission* [2002] ECR II-4945, paragraphs 196-221 (where it is stated that it cannot); and Case C-221/10 P, *Artegodan v. Commission and Germany* [2012], paragraphs 96-110 (where it is stated that it can).

dations – that maximize social welfare, not even the welfare of most citizens. They lack the adequate incentives to give due consideration to all interests at stake and to strike a fair balance between them. Let us remember that the limits of exposure set down in the ICNIRP Guidelines have not taken into account, *inter alia*, neither possible interference with medical devices at levels below the recommended limits nor the social costs and benefits of establishing such thresholds.

Private scientific organizations such as the ICNIRP often have an excessively homogeneous composition. The system of cooptation used to elect their members favours such homogeneity. That lack of plurality tends to reduce both the quantity and the quality of the available information that serves the basis of their judgments, to stifle critical dialogue, to exacerbate the common biases and positions of their members and to produce extreme outcomes, polarized in the direction of those biases and points of view.

Experts are not immune to the cognitive biases that other people commonly suffer from and that make them overly resistant to revise and change their opinions. Some of those biases affect experts even to a greater degree than laypeople.

Scientists tend to solve policy problems – e.g. setting limits of maximum permissible exposure to electromagnetic radiation – by applying purely scientific criteria. This is incorrect. The optimal degree of stability, discontinuity and responsiveness to new information does not necessarily have to be the same for scientific theories and legal rules. On the contrary, it is probable that the latter should be more elastic in that regard than the former ones. Even though new empirical evidence contrary to a mainstream scientific theory might not eventually constitute a sufficient reason to abandon such a theory at the purely scientific level, it may justify a change in the legal rules grounded in that theory.