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Mobile phone health risks

Controlling mobile phone health risks in the UK: a fragile discourse of compliance

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This paper describes the scientific/advisory discourse about mobile phone risk that was prevalent in the late 1990s. It argues that advisory responses to public concern constituted a 'discourse of compliance', which was strengthened by implicit support from the mobile phone industry. This discourse used compliance with advisory guidelines as the endpoint for discussions with the public. Evidence from non-experts and concerns about the basis of the guidelines were rejected. This discourse acted as a barrier to expert engagement with the public and with the broader context of uncertainties about the safety of mobile phones. The paper explains how this style of scientific advice was exposed as fragile, despite its claims to represent only the best available science, which, it was claimed, was well-understood and consensual.

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SCIENTISTS AND REGULATORS often express surprise at the level of public concern about mobile phones and their base stations, especially as there seems to be scant robust, scientific evidence pointing to their dangers. This is not to say that the science behind mobile phone risk assessment is consensual. As David Mercer (2002) has described, the science around mobile phones and other electromagnetic field (EMF)-generating technologies is characterised by long-standing disagreement among institutions and individuals, exacerbated by disputes between the scientific subfields (epidemiology, cell biology, radiation physics and so on) that approach the question of EMF risk (Miller, forthcoming).

Yet the vast majority of systematic reviews of the available science have suggested that there is only one effect that can be readily reproduced: a slight heating of body tissue. Concerns about mobile phone dangers are thus often dismissed as unscientific, based on an incorrect appraisal of the available evidence (see, for example, Burgess, 2004). The greater concerns over base stations are ascribed to public ignorance of the fact that base station exposure is typically orders of magnitude below mobile phone handset exposure. Frequent reassurances continue to remind the concerned public of this.

Explanations of the emergence of mobile phones as 'risky' have tended to use insights from psychometric risk perception studies, which suggest that the public views risks in a qualitatively different way from scientific risk assessment (for instance, Meara, 2002; Balzano and Sheppard, 2002), distorted by psychological bias or political values. Such models imply an unproblematic separation between 'evidence' and 'concern', between 'rational' and 'irrational'.

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The psychometric explanation for antipathy towards mobile phone base stations rather than handsets begins with the lack of control people feel they have over their exposure from base stations (for instance, WHO, 2002). Such explanations are sensible, and begin to address the politics of risk distribution, but they tell us little about the scientific uncertainties that are marshalled to defend claims of doubt or danger. Consideration of the growth of uncertainties in the public can explain the increasing legitimacy of such claims in a context of low public trust in scientific and advisory institutions.

This paper reports on a study of the mobile phones health controversy in the UK from the mid-1990s until the present day. This study involved documentary research of advisory reports and procedures and 31 semi-structured, anonymised interviews, most of which were with research scientists and advisory scientists whose work has contributed to the shaping of knowledge about, and policy towards, mobile phone risks. Through looking at the conditions of scientific knowledge and advice about mobile phones, this paper re-introduces cognitive elements of the public context of mobile phone risks. This contributes a richer explanation of the problems of credibility encountered by previously authoritative scientific advice.

Scientific advice and public science

In April 1999, Tessa Jowell, then Minister for Public Health in the UK Government, called for the formation of an independent group of scientific experts to consider the controversy over the possible risks of mobile phone technology. During the late-1990s, concerns about the safety of exposure to the weak EMFs generated by mobile phones and their base stations had reached Parliament, buoyed by frequent newspaper reports of people attributing their brain tumours to mobile phone use and of new scientific studies that, it was claimed, indicated danger.

During its deliberations and (albeit poorly-attended) public meetings, the Independent Expert Group on Mobile Phones (IEGMP) identified a problem of low trust in the National Radiological Protection Board (NRPB), which had previously managed advice and research concerning the health effects of mobile phones. The NRPB came under fire for its apparent narrow-mindedness in the consideration of scientific uncertainty and its rejection of non-expert considerations.

The report of the IEGMP (the Stewart report) criticised the NRPB's reactive approach to concerns and its unwillingness to "provide advice beyond a strict definition of what is and what is not a 'safe' level of non-ionising radiation" (IEGMP, 2000, paragraph 3.41). Although most of the general population were likely unaware of the NRPB, an institution built to provide the best available scientific input to policy, it became a key target for criticism from groups of non-experts engaged with the mobile phones health controversy. During the late-1990s, the NRPB's ability to provide credible, robust advice seemed to have slipped.

The intersection of scientific knowledge, expert advice and decision-making has been exposed in recent years as chronically problematic. In addition to academic literature, which has persuasively argued that the whole spectrum of risk construction is riddled with social framing assumptions (for instance, Jasanoff and Wynne, 1998), recent UK controversies over GM (genetically modified) foods (Levidow and Marris, 2001), BSE/CJD (bovine spongiform encephalopathy/Creutzfeld-Jakob disease or mad cow disease and its human equivalent) (Millstone and van Zwanenberg, 2001) and the MMR (measles, mumps, rubella) vaccine (Moore, 2003) have illustrated the shortcomings of scientific authority in settling questions of public concern.

Such controversies have confirmed the insight from constructivist analyses of science that scientific uncertainty is a malleable resource: rather than being the cause of social unease, it tends to be the product (Wynne, 1992). States of uncertainty about new products or processes often expand in unforeseen directions once controversies become public. Uncertainties that scientists might previously have been considered manageable or unimportant can become highly pertinent and problematic in the cold light of public controversy.

The limitations of expert advice have led many to call for broader participation in matters of scientific decision-making. Along with many others, Michel Callon (1999, page 86) has argued that:

> "Since science is at best incomplete, at worst unrealistic and, in any event, incapable of accounting for the complexity of the specific problems to which it is applied, it is advisable to open the forum for discussion and deliberation so as to create the conditions of its enrichment."

It has now become a rhetorical maxim that public dialogue (in whatever form) in scientific advice is necessary for the execution of robust policy, the aim being to re-establish some lost trust (House of Lords, 2000). Callon (1999) argues that a model of science in which the public is informed but ignored as active participants undermines itself by relying on trust that is not earned.

In controversial issues that are heavily dependent on expertise, we can expect policy intervention to

deconstruct (and reconstruct) areas of scientific consensus or uncertainty (Jasanoff, 1990). In public, science is tested according to its ability to accommodate (or resist) this kind of engagement. Science increasingly needs to be socially-robust (Nowotny *et al*, 2001; Nowotny, 2003), credible (Shapin, 1995) and authentic (Brown and Michael, 2002). Its robustness is measured according to the context of its application and production (Nowotny *et al*, 2001). The flexibility of science advice as contexts change is crucially dependent on an understanding of the multi-dimensional (scientific and political) nature of public engagement.

However, for experts, the temptation in the face of public challenge is to "retreat to stronger bastions of claimed social 'agreement' or 'black-boxing'" (Wynne, 1992, page 751; also Jasanoff, 1990), hardening a construction of 'science-' or 'evidence-based' authority and narrowing the definition of what counts as legitimate evidence. As I will explain in this paper, such a retreat is likely to harm the credibility of public science when its inflexibility is exposed by changing contexts. Too strong a boundary around scientific authority actively prevents engagement with non-scientists, which may encourage the search for alternative, unorthodox explanations, deepening controversy.

When mobile phones became a popular technology in the UK, the science of microwave safety seemed to have suggested little reason for concern over the past four decades. The known effects of microwaves only occurred at powers well above what was required by mobile phones. Responsibility for mobile phone regulation fell to scientists and institutions (such as the NRPB) with long experience of radiation protection in a range of areas. However, few could foresee the enormous increase in uptake of mobile phones.

In the late-1990s, when mobile phones emerged as a 'risky' technology,[1] ownership in the UK expanded from 9.1 million (1997/98) to 30.5 million (June 2000).[2] This expansion increased the visibility of both phones and base stations, as it necessitated more densely-packed networks to accommodate the high number of calls being made. In addition, the ubiquity of mobile phones raised the stakes for mobile phone regulation. A health risk even for a tiny subgroup of the population would have serious consequences.

Too strong a boundary around scientific authority actively prevents engagement with non-scientists, which may encourage the search for alternative, unorthodox explanations, deepening controversy

For the regulatory agencies charged with assessment of, and/or protection from, the risks of mobile phones, the context of knowledge about EMF risks was therefore altered by the popularity of the technology, with the result that assumptions and consensuses were re-opened for public consideration. What was known about the health effects of mobile phones began to re-examined.

A discourse of compliance

Mobile phones are generators of EMFs and emitters of electromagnetic radiation. In the UK, second-generation (digital) networks, which carry the calls of the vast majority of users, operate at frequencies of 900 and 1800MHz. This puts mobile phones between television signals and radar in the radiofrequency section of the electromagnetic spectrum, far lower in frequency and quantum energy than the known hazards of gamma rays and x-rays, which are classed as ionising radiation. Ionising radiation has sufficient quantum energy to break molecular bonds, a direct mechanism for carcinogenicity.

The only established hazard of non-ionising radiofrequency radiation is from excessive heating, caused by the rapid vibration of molecules such as water (the mechanism for microwave cookery). Protection against this heating effect is at the centre of 'what science knows'[3] about the risks of EMFs, and the central plank on which regulatory science is therefore based. In the UK, the NRPB is the body that determines, for all EMF-generating technologies, what a safe increase in temperature is and what level of radiation absorption produces such an increase.

Having worked primarily with ionising radiation safety issues for the previous two decades, the NRPB was forced to reconsider the issue of EMF safety in the early 1990s. A response was required to the controversy over the possible health effects of proximity to power lines, which generate extremely low-frequency (ELF) EMFs (50–60Hz). Concerns over the link between power lines and cancer were given weight by a leaked 1990 report from the American Environmental Protection Agency (EPA), which classified ELF EMFs as a "possible human carcinogen".

The NRPB realised that it was not well-equipped to respond to public concern in areas of non-ionising radiation, so it established the Advisory Group on Non-Ionising Radiation (AGNIR), with eminent epidemiologist Sir Richard Doll at the helm. Although the EPA report was never published, the power lines controversy established EMFs as an issue of public concern, and attracted interest from regulators and scientists, many of whom oversaw the start of the mobile phones controversy.

The report from AGNIR (NRPB, 1992) identified some areas of uncertainty in the science of EMF risk assessment, but provided the NRPB with no reason

to alter its existing guidelines. These guidelines suggested a restriction on the specific absorption rate (SAR), which would maintain temperature increases well within tolerable limits.

SAR provides a value for the rate at which electromagnetic energy is absorbed by a unit mass of biological tissue. SAR restrictions were constructed as the best available numerical representation of what was known about the thermal hazards of EMFs. However, they took no formal account of uncertainties that existed about the possibility of effects occurring without significant heating. These non-thermal effects of EMF exposure have been detected for as long as anyone had cause to worry about their implications. As one radiation physicist told me:

> "There have been reports on non-thermal effects ever since I've been working in the field, which is 50 years now. This is nothing new."[4]

Non-thermal effects have tended not to be reproducible between laboratories, prompting disagreements about the reality of the effects and the quality of replication. Yet the uncertainty surrounding these effects gained new prominence in the light of fresh worries over mobile phone safety. The NRPB, granted responsibilities as a dual research and advisory organisation, considered these uncertainties sufficiently interesting to prompt further research, but not to affect the flavour of scientific advice, which followed what I call a 'discourse of compliance'.

In the late 1990s, the number of mobile phones soared, along with the number of base stations required to maintain effective networks. At the same time, worries about health protection reached the public through aggressive reporting by news media (Stilgoe, 2001; Burgess, 2004). New studies claiming to demonstrate non-thermal effects attracted media attention, with the implication that SAR restrictions, based entirely on thermal effects, were inadequate for public protection. In addition, there was an explosion in the number of individual reports of harm from mobile phones. Newspapers and individuals attributed brain tumours to mobile phone usage, and a number of people reported a variety of sensitivities to weak EMFs that could not be explained by conventional scientific models.

As I suggest in this paper's introduction, the robustness of scientific advice is tested by the questions that are asked of it. The NRPB was the usual first-call for questions about EMF risks from journalists, politicians and the general public. In the late-1990s, an increasing number of these enquiries related to mobile phone concerns, particularly about exposure from base stations (IEGMP, 2000, chapter 3).

Questions about the regulatory implications of these new areas of doubt tended to elicit the response that all mobile phone technology complied with SAR guideline levels, which had a well-established basis, so there was no reason to worry. This type of response, based around reassurances of compliance, became the accepted way of handling such concerns.

In this paper, I use the word 'discourse' in its Foucauldian sense to describe this way of talking about mobile phone risk, but also to illustrate the attempt by advisory scientists to restrict the terms of scientific debate.[5] The science was seen to be sufficiently strong and SAR guidelines, as numerical representations of the best-available science, should be authoritative. Nevertheless, as the mobile phones controversy gathered pace and publicity, this prevailing discourse began to be challenged in a way that was both 'scientific' and 'political'.

Compliance and labelling

The public context of mobile phone health concerns prompted policy debate in a number of areas, including whether more information should be made available to the public about mobile phone technology. Researchers for an episode of BBC TV's 'Panorama', broadcast in May 1999, had revealed large differences in SAR levels between different models of handsets (all of which were nevertheless below the basic restriction level). The programme therefore suggested that, as a precautionary measure, consumers might appreciate the choice of a handset based on a lower-than-average SAR. A label on the mobile phone's box, or on the phone itself, would inform the customer of the SAR level.

A month after Panorama was broadcast, the House of Commons Select Committee on Science and Technology held meetings to discuss the issue of mobile phones as part of a parliamentary review of the provision of scientific advice. As part of the industry's evidence to the committee, David Brown, the Chairman of Motorola in the UK, responded to the question of informing the public about SAR values on phones:

> "… the important thing is to be able to state categorically that the mobile phones meet the SAR standards set by the NRPB and not then go on to risk confusing the public about what relative SARs below the safe level really mean … we think it is entirely inappropriate to put precautionary health labels on products for which there is no evidence to suggest they are unhealthy. That would be to deepen the mischaracterisation issue of the underlying science. Mobile phones are safe and that is that … They are all safe."[6]

The director of the NRPB, Roger Clarke, giving evidence to the same committee, gave a similar impression, albeit less forcefully:

> "From a radiological point of view I believe that all marketed telephones meet our exposure

guidelines and as such there is no need for any further consideration."[7]

These comments typify the discourse of compliance. They reveal a sharp distinction between areas of public and expert concern, with both the NRPB and the industry considering questions about relative SAR levels to be illegitimate. I asked an industry representative about labelling phones with their SAR values:

> "We don't believe that's the right way to go, because that undermines the existing regulatory regime … it's confusing to consumers. There's no rationale to say that a phone with a SAR level of 1 rather than a SAR level of 2 [watts per kilogram], there's no relative safety, because SAR was always a pass/fail test … The important thing for us is that, whatever we do, it's fact-based."[8]

This comment, that SAR guidelines represent a pass/fail test, reveals the prevailing industry and regulatory view that the only relevant level of absorption is the one at which known (thermal) effects might begin to pose a problem. Below this level, because reproducible effects with known health implications cannot be detected, any differences in SAR are irrelevant. Public concerns, or demands for a phone with a low SAR value (at, for example, a tenth of the guideline value) are seen as unwarranted, based on erroneous assumptions. This logic sees labelling phones as a challenge to the scientific consensus without good (scientific) reason.

These quotes illustrate the prevailing discourse, and the space that was allocated for non-expert debate. The whole field of measurement — constructing SAR — was cordoned off by expertise, with the non-experts left only with the question, "Does it comply?" According to this discourse, the introduction of labels is therefore inviting non-experts to make decisions that they are not cognitively equipped to make.[9]

The 'science-based' guidelines and the discourse of compliance around them allowed industry to largely ignore health issues. Industry was not considered a part of this consensus. Indeed, it strove to prove its independence from the science that seemed to exonerate its technologies, despite having provided much of the research funding in the 1980s. The NRPB in turn insisted that the guidelines were 'science-based', as opposed to 'technology-based'. Engineering considerations of mobile phones were ostensibly far removed from determining 'safe' levels of absorption. Tom-Wills Sanford, from the Federation of the Electronics Industry, representing mobile phone network operators, was asked by the Select Committee for his attitude to the NRPB's guidelines:

> (Michael Clarke, [Committee chair]) "The National Radiological Protection Board (NRPB) has a set of guidelines which are generally looking at the thermal effects from mobile phones. Do you think these standards should be revisited? Are they something which should be updated in light of the large use now of mobile phones and the proliferation of them?"
>
> (Tom Wills-Sandford) "We are very happy to leave that judgement to the NRPB. We have great faith in them and, as our memorandum says, we believe there is a large number of highly respected international scientists in the NRPB, so we are very happy to leave that judgement to the NRPB."
>
> (Michael Clarke) "You are just interested in selling phones and you do not really care about the standards to which they are sold. You leave that to somebody else."
>
> (Tom Wills-Sandford) "Not at all. We are interested in selling phones and services and so on which comply with internationally agreed guidelines."[10]

Compliance with international guidelines is taken into account at the early stages of the engineering process.[11] The handsets are usually sold across many countries and many regulatory regimes, so they must comply with international guidelines. These were set by the International Commission on Non-Ionising Radiation Protection (ICNIRP) and were marginally more stringent than the NRPB's equivalent.

However, the major incentive to keep SAR down is one of efficiency. Radiation absorbed by the head is a waste of energy that could be used to extend battery life. As one representative of a mobile phone manufacturer told me, "We're not in the business of heating heads".[12] So, within the discourse of compliance, a reduction in the SAR value of a handset could be defended on the grounds that it makes for a more efficient phone. The relative safety of the technology did not need to be addressed. Industry, once it demonstrated compliance (and only poorly-engineered technology would approach the guideline SAR level), did not need to consider the science.[13]

The 'science-based' guidelines and the discourse of compliance around them allowed industry to largely ignore health issues: industry strove to prove its independence from the science that seemed to exonerate its technologies

Within the discourse I have described, the only reasonable grounds for debate were whether a technology complied with the guidelines. The central problem was therefore framed as one of measurement. This raised uncertainties connected with dosimetry (the calculation of how and how much radiation is absorbed for any given exposure). However, the NRPB policed these aspects of the discourse of compliance. Indeed, resolving these uncertainties and accurately determining compliance was vital for the preservation of authority. Other areas of uncertainty were less easily controlled by experts.

Uncertainty and 'science-based' advice

The discourse of compliance represented what was known about mobile phone risks, and what the acceptable form of debate was about these risks. In this sense, it was a way of obscuring uncertainties that might have proved problematic (with public (mis-)interpretation) to the provision of authoritative advice or to the mobile phone industry. However, uncertainties were explicitly addressed as a need for further research. When the NRPB's director, Roger Clarke claimed to the House of Commons Select Committee that "all marketed telephones meet our exposure guidelines and as such there is no need for any further consideration", he meant that there was no need for consideration by anybody outside the citadels of expertise. The uncertainties that existed were not considered to have any implications for public health policy.

> "Oh, there've always been hints of things. In '91 and '92 we did reviews of biology, so it was at least ten years ago … but nothing conclusive. Nothing that you would want to lose sleep over … but it's just, there's always been hints."[14]

The uncertainties discussed by this NRPB scientist are around the non-thermal effects on humans, animals and cell models that were detected below guideline SAR levels. Uncertainties over non-thermal effects occupied researchers, but had no representation in UK scientific advice. As one member of AGNIR told me, "They didn't fit into the model to determine finite, numerical standards".[15]

Such uncertainties, however, despite their lack of mechanism and their lack of replicability, were expanded in public to represent evidence of possible harm. Louis Slesin, the editor of *Microwave News*, a well-respected campaigning journal dedicated to issues of EMF safety, told BBC's Panorama, "Once you open that Pandora's Box and allow that microwaves at these levels can have these effects, then you have to ask the next question, what else can it do?"[16]

Non-thermal effects, along with individual reports of harm from mobile phone use, challenged the assumptions behind the regulatory orthodoxy. Although the NRPB insisted its advice was "science-based", 'scientific' questions were asked as to why, for example, SAR calculations assumed that everybody would react to EMFs in the same way. The possibility of more susceptible members of the population was not considered. In addition, SAR dosimetry assumed only an acute effect rather than a chronic one.

Handsets and base stations

Consideration of this latter assumption suggests an explanation for the uncertainty behind an important locus of public disenchantment — the base stations that make up mobile phone networks. SAR provides a metric for the assessment of hazard from an acute, thermal exposure. SAR expresses a dose rate rather than the cumulative dose absorbed by the human body. After the six minutes of exposure required to reach equilibrium temperature, the time exposed to radiation is ignored. It is therefore considered unimportant whether a person is exposed for short or long periods. The questioning of this assumption allows us to tie scientific uncertainty to the antipathy that was expressed against mobile phone base stations, which attracted (and continue to attract) vociferous protests and claims of harmful effects.

The highest base station exposure is typically thousands of times beneath the NRPB's guideline levels: far too weak to induce an acute heating effect. Yet many of the concerned public considered that long-term (chronic) exposure was risky, and would not be reassured by assurances of compliance with a metric based on acute exposures. For these people, the discourse of compliance was not answering their questions.

As explained above, the discourse of compliance did not entertain public consideration of the assumptions behind SAR guidelines. Other groups (anti-phone mast pressure groups, unorthodox scientists and news media) were more open to such uncertainties. So there was temptation for disenchanted members of the public to disperse their trust. One scientist, who firmly believed current SAR guidelines were justified, explained the situation:

> A: "Yeah, well this is the government, the industry and the NRPB's agreed way to deal with the health issue. It's just to talk about the limits. And if you say 'gee, I think I'm having epileptic seizures, or my memory's slipping, is it that bloody radio-antenna?' they'll say 'you know, my dear, we're operating below the guideline limits, here's all the information, here, here, here and here'"
>
> Q: "So how do you address their concerns without undermining your own guidelines, which you seemingly said are sufficient as they stand?"
>
> A: "Well, that's a very good question, but you have to take into your head that in the last ten years, most of the research has been on the

> guideline limits, and the industry and government are paying for this research and they're not discussing it with the public, … as a result, the people like the activists who come in and tell them 'yes, we know this is a worry and we're going to tell you you're gonna get cancer problems and cognitive effects and all this kind of thing.'… The NRPB and the industry have all agreed not to talk about it, so the people are left with a vacuum… And then you go and talk to somebody who you think might know a little more than you do but isn't quite the established source, and they tell you all the other things, you begin to believe them."[17]

The discourse of compliance, by demarcating certain areas for the consideration of scientific uncertainties, prevented public engagement on the issue of greatest public concern — mobile phone base stations. The public was largely powerless in decisions to erect base stations, many of which (those less than 15 metres high) had been granted 'permitted development rights' by the Telecommunications Act (passed in 1984 by a Conservative government eager to ride the economic wave promised by mobile telephony).

Testimony taken from the IEGMP's public meetings frequently tied the lack of control of base station location to doubts about the long-term safety of EMF exposure. Concerned mobile phone users could reduce their exposure straightforwardly, but people living near base stations could not. This skewed distribution of risk suggested that the issue of base stations required greater engagement on areas of public concern, but many of the public were effectively told by advisory scientists that their concerns could not be legitimately addressed (or even held).

Reported symptoms

Many people living close to base stations reported symptoms arising from their continuous exposure to weak EMFs. Similarly, many mobile phone users reported headaches, dizziness, memory loss and a host of other ailments during or after calls. According to the thermal model of biological effects, such fields should not be harmful and they should not be detectable. However, in the context of low trust in expertise, such symptoms were seen by interest groups, sufferers and some scientists to indicate worrying areas of uncertainty about vulnerable or sensitive subgroups of the population.

The NRPB developed a reputation for rejecting such symptoms as merely "anecdotal evidence" (Stilgoe, 2002). The UK conducted much less research into possible sensitivities to EMFs than other European countries (Sweden, in particular). For those reporting symptoms, this rejection reinforced an impression of an unresponsive organisation defending a scientific consensus and a regulatory regime that did not accommodate the uncertainties that were relevant to public health.

The rejection by the NRPB of reported symptoms from base station exposure reinforced an impression of an unresponsive organisation defending a scientific consensus and a regulatory regime that did not accommodate the uncertainties that were relevant to public health

The discourse of compliance imposed control of the cognitive authority of both science and regulatory guidelines through control of uncertainties. The areas demarcated for the consideration of uncertainty (and the provision for further research) did not, however, match those considered important by non-experts in settling issues of concern. The discourse of compliance failed to answer the questions that were being posed by the public. The explanation offered here of the role of uncertainty in picking apart two examples of concern (base stations and reported symptoms) suggests a mechanism for the loss of public credibility experienced by the NRPB.

Conclusion

This paper has shown how a consensus, based on a well-established heating effect, can become constructed and formalised in a set of guidelines, which obscure areas of uncertainty. The NPRB considered its standards to be scientific advice, rather than regulatory prescription. The ostensibly political responsibility was passed to Government. The NRPB, through its guidelines and advice, claimed only what conditions were considered safe by the weight of scientific evidence, but the guidelines and the consensus behind them became mutually representative and reinforcing. The guidelines represented what was known, acting as an "anchoring device" (van der Sluijs *et al*, 1998), one stage removed from the scientific evidence, preventing undue movements in the representation of scientific uncertainty.

Challenges to these guidelines, implicit or explicit, produced a defensive reaction by both the NRPB and the mobile phones industry, which reveals a prevailing attitude amongst scientific and regulatory orthodoxy that compliance with thermally-based guidelines promised safety. This discourse of compliance allowed regulatory agencies to manage the issue as a scientific one, with a single answer.

The decision as to public acceptability was taken on behalf of the public. The discourse set the bounds for legitimate debate, preventing non-scientific

bodies (including industry) from questioning the framing of the guidelines. Uncertainties remained an expert resource, with the implication that absence of (robust) evidence was equivalent to evidence of absence of harm.

Such a discourse of compliance has clear practical advantages if a technology remains uncontroversial. It gives the impression of stability and control. As I have mentioned, industry can defer to external expert authority rather than assuming responsibility for protection. The discourse of compliance deflects the possibility of litigation by restricting the space for legitimate dissent. Mobile phone companies have tended to be very successful in avoiding tort claims in this way.[18] However, this pattern of authority can be undermined once the interests behind such discursive tactics are exposed.

This paper has demonstrated how a discourse based on 'compliance means safety', can be challenged in a way that is simultaneously 'scientific' and 'political', questioning both the scientific consensus and the choices taken in extrapolating states of knowledge and uncertainty to guidance about safe levels. In the public arena, 'black-boxed' framing assumptions were re-opened, new questions were asked. What technologies were the guidelines originally intended to cover? What are the grounds for scientific consensus? What direction should research take? The door between risk assessment and risk management, which the public had previously seen from the outside in the form of SAR guidelines, was prized open through broader engagement around issues of policy and scientific uncertainty.

Uncertainty has always existed around the consensus that thermal effects are the only harmful effects of EMF exposure. At a laboratory level, such uncertainties have always been understood (indeed they are the lifeblood of productive new research). Yet such contingencies were lost within the advisory system. Many experts assumed that they were meaningless outside the scientific community.

This perception that scientific uncertainty is solely an expert consideration is a crucial part of the discourse of compliance, and a crucial part of its downfall. Public challenges to SAR guidelines were seen as 'political'. The technical aspects of public engagement, in which salient uncertainties were unpicked, were largely ignored by scientists (as they have been by some social scientists (for instance, Burgess, 2004)).

We have seen how scientific uncertainty expands with public concern about a rapidly-growing technology. Uncertainties that might concern experts, such as the ability to measure doses accurately, or the presence of niggling non-thermal effects, can be augmented and picked apart until advisory guidelines and a scientific consensus appear unstable. In addition, public engagement can prise open areas of uncertainty that experts do not seem to be considering, such as the effects of chronic exposure to EMFs, or the possibility of vulnerable subgroups of the population.

The more a regulatory philosophy is challenged, the greater the temptation for regulatory science to harden it as an apolitical representation of a scientific consensus. However, the authority that might seem to come from being 'science-based' is fragile. Organisations such as the NRPB, which consider that their role as solely to reflect the best available science, find themselves unwittingly representing a political position. People who approached the NRPB and similar bodies with worries about the protection afforded them by current safety guidelines were greeted with the discourse of compliance, which failed to answer, or even acknowledge, the questions they were asking.

The responses only reinforced the impression that the two groups with previous interests in the scientific consensus — the NRPB and the mobile phone industry — were less independent than they had claimed. A comment from Alastair MacKinlay, head of the non-ionising radiation division at the NRPB and chairman of ICNIRP, at a meeting held to encourage further harmonisation of international EMF health standards in 1999, indicates that the NRPB was aware of the limitations of relying on a public discourse of compliance:

> "Dr McKinlay pointed out that it was important for standards to [be] clear about what health effects they provide protection [from]. All too often authorities hide behind standards to avoid answering the real concerns held by people."[19]

However, the NRPB's desire for reliable, stable scientific advice made a rod for its own back. In the face of fervent public controversy, the NRPB could only maintain its established position of 'science-based' advice. An NRPB interviewee explained this problem, and the need for *ad hoc* expert groups:

> "We're an independent statutory body, but, if an organisation says one thing one year, it is hard for it to change its mind, so we have these expert groups which could facilitate that programme, and also it assures the public, or should do, and politicians that we are impartial, and on difficult questions we get people who are separate from us."[20]

The credibility of public science is tested by the questions that are asked of it, often by non-experts. As the context surrounding mobile phone regulation changed, the NRPB's advice no longer fitted the types of question that were being asked. Originally expected by the UK Government to be a source of authority, and of high quality science, the NRPB became a target for criticism, unsure of its role in a broader debate.

The NRPB's natural style of advice was harm-based, working from the known dangers of ionising radiation or intense microwave heating. It was less well-equipped to deal with the risk-based style of

regulation (considering the possibility of harm) demanded by the context of the mobile phones controversy (see Jasanoff, 1995, page 72) for more on this distinction).

The collapse in the public credibility of the NRPB's advice (identified by the Stewart report) can be ascribed to the surprise of a changing context. The public context of previously-expert discussions of uncertainty highlighted the social fragility of the discourse of compliance. New contexts produce new uncertainties and new questions.

The massive expansion in mobile phone use meant more people were affected by the technology, which raised the standard for adequate knowledge about risks. Yet public questions about possible effects below guideline limits were not afforded legitimacy by the discourse of compliance. The test of 'social-robustness' is the ability to deal with these unforeseen contexts (Nowotny *et al*, 2001). As learnt most pointedly by the GM food industry, institutions must be ready, willing and able to accommodate engagement on cognitive and political terms to understand these contexts (Levidow and Marris, 2001).

Despite a desire for accountable, 'science-based' or 'evidence-based' decision-making, advisory scientists should appreciate that authority might not earn credibility if the broader context of a controversy changes. Advisory scientists should seek the best available evidence, but they should be aware of what is not being taken into account in doing so. All advice that is considered rational necessarily involves a raft of decisions, which are often opaque, that cannot easily be defended on the grounds of rationality. As predicted by recent social theory, attempts to construct domains as apolitical lead to new, unforeseen areas of contestation (Barry, 2001). New contexts can expose 'science-based' rationale as politicised.

This paper has contributed an explanation of the flexibility of scientific uncertainties in defining a public scientific controversy. This allows us to understand how, when trust in scientific advice is low, the potential for uncertainty to be allied to claims of harm is more important than the 'balance' of existing evidence. The explanation offered here provides the background for more recent policy discussions, which I will consider elsewhere, about the risks of EMFs, which have been characterised by disputes as to the level of uncertainty and the possible place of precautionary policies for EMF risks (for instance, NRPB, 2003).

Notes

1. A survey in June 1999, funded by Techno AO (manufacturers of a device that sticks to the back of a mobile phone and claims to reduce radiation exposure), found that 43% of daily users were particularly concerned about the potential risks from mobile phones (Market and Opinion Research International: "Nearly half of frequent users of mobile phones fear health risks", press release, 3 June 1999, available at <http://www.mori.com/polls/1999/tecnoao.shtml>, last accessed 10 November 2003).
2. By 2003, mobile phone usage was beginning to level out at about 50 million (75% of the UK population) (Statistics of mobile phone ownership from the web site of the Mobile Operators' Association, <http://www.mobilemastinfo.com/information/history.htm>, last accessed 27 October 2003).
3. This phrase is borrowed from Steven Epstein's (1996) description of the facticity of HIV causing AIDS. Epstein in turn borrows the phrase from Patton (1990).
4. Interview transcript, no 31.
5. Philp (1990, page 68), summarising the key contributions of Foucault, states that 'discourse' in the Foucauldian sense, is "… best understood as a system for the possibility of knowledge". A discourse is based on rules, but these are not consciously followed. They operate "'behind the backs' of the speakers of a discourse" (ibid).
6. Minutes of verbal evidence to the House of Commons Science and Technology Select Committee, 16 June 1999.
7. Minutes of verbal evidence to the House of Commons Science and Technology Select Committee, 9 June 1999.
8. Interview transcript, no 25.
9. Lisa Mitchell and Alberto Cambrosio have tackled the issue of how concerned non-experts measure, and make visible, EMFs, building a representation of riskiness that previously was only available to experts (Mitchell and Cambrosio, 1997).
10. Minutes of verbal evidence to the House of Commons Science and Technology Select Committee, 16 June 1999.
11. The International Commission on Non-Ionising Radiation Protection sets international guidelines for SAR restriction. The regulatory philosophy is akin to the NRPB's, except that a five-fold safety factor is included for whole-body exposure in the general public, as opposed to occupational exposure, which is the same as the NRPB guidelines. This additional safety factor is included to accommodate the possibility of sensitive subgroups of the population.
12. Interview transcript, no 25.
13. Similarly, the NRPB attempts to create distance from industry by emphasising that its guidelines restrict absorption of radiation, not emission (personal communication, NRPB scientist).
14. Interview transcript, no 32.
15. Interview transcript, no 6.
16. BBC 'Panorama' transcript, 24 May 1999.
17. Interview transcript, no 27.
18. Thanks are due to an anonymous reviewer for this point.
19. Minutes of International EMF Project: Standards Harmonization Meeting, Ettore Majorana Centre, Erice, Sicily, Italy, 27 November 1999.
20. Interview transcript, no 21.

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