The (co-)production of public uncertainty: UK scientific advice on mobile phone health risks

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UK scientific advice on the possible health risks of mobile phones has embraced (or seems to be embracing) broader engagement with interested non-experts. This paper explains the context of lost credibility that made such a development necessary, and the implications of greater engagement for the construction (and expert control) of "public concern." I narrate how scientific advice matured from an approach based on compliance with guidelines to a style of "public science" in which issues such as trust and democracy were intertwined with scientific risk assessment. This paper develops existing conceptions of the "public understanding of science" with an explanation based around the co-production of scientific and social order. Using a narrative drawn from a series of in-depth interviews with scientists and policymakers, I explain how expert reformulation of the state of scientific uncertainty within a public controversy reveals constructions of "The Public," and the desired extent of their engagement. Constructions of the public changed at the same time as a construction of uncertainty as solely an expert concern was molded into a state of politically workable public uncertainty. This paper demonstrates how publics can be constructed as instruments of credible policymaking, and suggests the potential for public alienation if non-experts feel they have not been fairly represented.

1. Introduction

Over the past decade, the United Kingdom has seen mobile phones emerge as a "risky" technology (defined popularly rather than scientifically). The possible health effects of the mobile phone and its attendant technologies have attracted a huge amount of media attention. News stories, especially in the tabloid media, have typically connected public experiences of harm with reports of new scientific studies. These studies purport to indicate unexpected biological effects from mobile phone radiation, challenging orthodox assessments of risk, which have been based on the known effects of microwave radiation. Public concern about mobile phones and base stations (both of which are increasingly numerous) has tested the adequacy of scientific knowledge in this area and questioned prevailing definitions of relevant uncertainty.[1]

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What research has been done on mobile phones as a "risk issue" (Leiss, 2001) has largely failed to problematize the scientific elements of this controversy (e.g. Burgess, 2004), even though it is unavoidably rooted in science. The conclusion drawn from such explanations is that the public controversy is akin to a "moral panic," with the mobile phone as a condensation point for amorphous concerns and misconceptions about technology, trust and control. It may well be that the case of mobile phone risks tells us a good deal about the hopes and fears of contemporary society. However, an analysis of the full spectrum of risk, including the science behind risk analysis, reveals that there is no clear demarcation between scientific and public concerns.[2] Just as public concerns are justified according to apparently crucial gaps in scientific understanding, so areas of scientific interest are justified by public interest in robust knowledge about risk.

In this paper I consider how, as experts assess the state of knowledge (and uncertainty) about a contemporary risk issue, they also legitimize, co-opt, reject or otherwise construct areas of "public concern." This paper focuses on the experts who have been charged with advising the UK Government and the UK public about mobile phone risks. It forms part of a larger project, which considers how experts made sense of bodies of public concern and bodies of scientific knowledge about the health effects of mobile phones in their efforts to provide authoritative and credible scientific advice. This project, conducted between 2000 and 2004, was funded by a Ph.D. grant and subsequent postdoctoral fellowship from the UK Economic and Social Research Council.

The research consisted of 31 interviews, most of which were with research scientists or advisory scientists involved with analyzing the health effects of mobile phone radiation. An initial interview sample, drawn from experts involved with the main scientific advisory reports on the issue, was augmented with "snowballed" recommendations from interviewees. Other sources, such as mailing lists, web sites, scientific literature, advisory reports, published committee minutes and recently opened archive records of the Independent Expert Group on Mobile Phones, complemented interview data.

2. Constructing publics

In recent years, a number of prominent public controversies have highlighted the problems of constructing authoritative scientific advice in a context of public distrust. Expert pronouncements of safety are more likely than ever to be scrutinized and questioned by media, non-governmental organizations, branches of government and concerned members of the public. We can attribute distrust to broad social changes, which heighten an appreciation of risk and question our relationship to the expert institutions of modernity (Beck, 1992) and/or to recent events which have defaced the public image of the scientific experts who are expected to provide answers to novel problems (the clearest example in the UK being the mismanagement of the bovine spongiform encephalopathy (BSE) crisis (see Millstone and Van Zwanenberg, 2001)). Either way, it now seems clear that a reliance purely on science is not sufficient for the provision of credible scientific advice. Such controversies have bolstered the argument that credible, robust policymaking demands non-expert participation in scientific debate and an understanding of the context of technology-in-society.

In the 10 or so years since the BSE crisis, the call for broader participation in UK science policy has become accepted as a maxim, formalized in the *Science and Society* report from the House of Lords' Science and Technology Select Committee. The report, recognizing a "crisis of trust" in scientific decision-making recommends:

> That direct dialogue with the public should move from being an optional add-on to science-based policy-making and to the activities of research organisations and learned institutions, and should become a normal and integral part of the process. (House of Lords, 2000: paragraph 5.48)

This paragraph, coupled with more recent calls for public debate to move "upstream" (Wilsdon and Willis, 2004; Royal Society, 2004), represents a significant shift in the consideration of the "public understanding of science." In the UK, this term was coined and formalized in the 1980s to advocate improved education in the ways of science—with the hope that the public would not be so quick to disagree with scientific understandings of, for example, risk issues (see Royal Society (1985) for an important example). As a logical extension to this model of science and the public, science was imagined speaking "truth to power" on controversial issues (Irwin and Michael, 2003). In the 1990s, this "deficit model" of public understanding provided a target for social scientific critique that took its inspiration from studies of science that emphasized the constructed, contested and contingent nature of scientific knowledge. Drawing on the insights of the sociology of scientific knowledge (SSK), social scientists turned their attention to the local contexts in which scientific knowledge is both applied and produced (see Irwin and Wynne, 1996).

Brian Wynne, the pre-eminent critic of the deficit way of thinking about the relationship between science and its publics, has argued that the theoretical alternatives to the deficit model of science-in-society lack theoretical cohesion (Wynne, 1993). Studies of science-in-context have suffered from a need to emphasize the local circumstances of each scientific controversy. Ethnographic public understanding of science has largely been based on case studies, one of the major criticisms of deficit thinking being its reliance on "authoritative" survey techniques demonstrating public ignorance (Irwin and Michael, 2003). Wynne advocates turning the traditional public understanding of science model on its head. Rather than focusing on questions of public ignorance or the public's perceptions of scientists, we should examine the extent to which experts construct The Public (Wynne, 1993: 322). As Wynne has explained on many occasions, the deficit model of public understanding of science can be seen as nothing more than an expert attempt to explain away public concerns with recourse to an image of an unqualified and ignorant public. In this sense, a view of the public and of public concern can be seen reflected in views of the reliability and completeness of scientific understanding.

Studies of technology have suggested that technologies necessarily embed assumptions about users (Woolgar, 1991) (and sociologists embed assumptions about readers (Latour, 1988)), *constructing* their particular public. So experts, when dealing with questions of public engagement, might be seen as (re-)constructing their publics as they (re-)construct science-in-public.

As the most recent international challenge to naive conceptions of expert advice, the controversy over genetically modified organisms (GMOs) has attracted a good deal of scholarship looking at the representation of publics. Hill and Michael have considered how surveys of public opinion on biotechnology effectively construct an amenable "public" as hybrid citizen-consumers, which allows public acceptance to be, to an extent, engineered (Hill and Michael, 1998). Similarly, Rob Doubleday has looked at one GM firm's efforts to reconfigure its relationship to the public by seeing them as "consumer-citizens." But this instrumental view of the public does not account for the tensions that emerge from the different roles played by any non-expert in the GM controversy (Doubleday, 2004). Maranta et al. have studied experts' conceptions of lay people as they try to put together "socially-robust" knowledge (see Nowotny et al., 2001) across a range of public scientific situations.

These “Imagined Lay Persons” are grown from a seedbed of assumptions about knowledge, communication and participation (Maranta et al., 2003).

Wynne, also looking at the GMO debate, has considered how institutional representations of The Public provoke alienation, which contributes significantly to the shaping of non-expert engagement with science (Wynne, 2001). As we will see with the mobile phones example in this paper, we can understand the credibility of scientific advice in terms of public reactions to expert representations of publics and public concern. But, as will become clear, these expert constructions of the public are reinforced and justified by representations of science. In particular, representations of the nature and relevance of scientific uncertainty are a crucial contested area.

3. Constructing uncertainty

Any novel technology will open up new doubts and ask new questions of the adequacy of scientific understanding. In any technological risk issue, discussions of uncertainty (or ignorance) are just as important in the representation of scientific reality as discussions of knowledge (Stocking, 1998).[3] The realization that arguments about scientific uncertainty are a central feature of contemporary public science has prompted some important scholarship.

Constructivist studies of scientific knowledge have supported the claim that there is no “real” uncertainty in a public science controversy. Uncertainty only exists as that which emerges from negotiations about the adequacy and relevance of current knowledge. Rather than simplistically attributing a public science controversy to expert uncertainty or disagreement, we can see scientific uncertainty as determined in part by disagreement and high stakes within a controversy (see Campbell, 1985; Jasanoff and Wynne, 1998). This more sophisticated view of uncertainty grows from an appreciation of both the normality and the contentiousness of areas of incomplete knowledge. Within the scientific community, there may exist agreed-upon uncertainties, which are the lifeblood of research. Indeed, Susan Leigh Star has pointed out that the management of local uncertainties, while striving for global certainty, is one of the central aspects which defines scientific work (Star, 1985: 393). But uncertainty reveals itself in a more problematic sense in the public domain. In contested, interdisciplinary domains, “scientific uncertainty is not only a reflection of what scientists are uncertain about; rather . . . it can be constructed through scientists’ individually clear and concise but variable accounts of nature” (Zehr, 1994: 215). And the continuing attempt to resolve uncertainties will shed light on new areas of uncertainty (Ravetz, 1986). The extension of a controversy beyond an existing group of experts will tend therefore to pick apart areas of uncertainty. Scientists’ control of uncertainty in the public domain is crucial. After all, there seems little point in seeking expert advice if experts are plagued by the same uncertainties that concern the public and policymakers (Zehr, 1999). Scientists will therefore aim for a degree of social control of uncertainty, as there is always a danger that “technical uncertainty” may become, or be perceived as, “social uncertainty” (Jasanoff and Wynne, 1998).

This is not to say that uncertainty is simply an embarrassment that scientists strive to hide from expert view. Uncertainty only becomes a problem when someone authoritatively decides that it has problematic implications (Wynne, 1987). Uncertainty is a necessary point of discussion in maintaining the relationship (and separation) between science and policy (Shackley and Wynne, 1996; Jasanoff and Wynne, 1998: 76). But uncertainty can also be used by experts to demarcate scientific and public worlds, by emphasizing the authoritative

definition of the state of knowledge and the necessary direction for exploring areas of ignorance (Zehr, 2000).

As we shall see, there is no easy way to retain control over uncertainties in public controversies. This raises problems for robust precautionary policies, which may be advocated based upon a degree of scientific uncertainty. Calls for precautionary approaches to regulation are often supported by claims of high scientific uncertainty, high public concern or, most likely, both. This paper problematizes both of these areas, and so sheds some light on recent debates about the uses (and abuses) of precaution for political ends. Les Levidow has made the point that just as uncertainty is used to justify precaution, so precautionary approaches might be used to justify uncertainties (Levidow, 2001). I would add that arguments over precaution also construct and operationalize rigid constructions of The Public and use them to justify or denigrate policy options. It seems clear that these issues will provide a central challenge to policymakers, analysts and theorists over the next few years. The case of mobile phone risks provides us with an early example of how reflexive British experts, standing in the long shadow of BSE, reconstruct uncertainties and publics as they look for control of a controversy.

4. The NRPB: compliance and a thermal consensus

Before the existence of mobile phones, UK responsibility for providing scientific advice on any technology that generates electromagnetic fields (EMFs) lay with the National Radiological Protection Board (NRPB). With the development and subsequent popularity of mobile phones, the NRPB considered its guidelines, which covered the band of the electromagnetic spectrum into which mobile phone frequencies fell, more than sufficient to guarantee safety. These guidelines were designed to prevent any significant heating effect occurring from the microwaves emitted by mobile phones. This thermal effect was the only effect that could be consistently replicated in scientific studies and the only possible effect with a well-understood mechanism of interaction. The harmful, carcinogenic effects associated with ionizing radiation such as gamma rays and X-rays did not apply to microwaves, because of microwaves' much lower frequency (and therefore power). Microwaves, as "non-ionizing" radiation, were considered safe once thermal effects had been accounted for.

Despite this apparent consensus around replicable effects, there remained scientific uncertainties that could be unearthed to both prompt and justify claims of harm from mobile phone use. Doubts about the presence of *non-thermal* effects (occurring below guideline levels and so not attributable to heating) have a history as long as that of the science of EMF safety. The replication of these effects would undermine the regulatory philosophy of institutions such as the NRPB. But such effects tended to be viewed as scientifically interesting rather than worrisome, especially since, as NRPB scientists explained to me, there is a large leap between demonstrating a *biological* effect and demonstrating a *health* effect. An early NRPB report (before mobile phones became popular or controversial) discussed these uncertainties:

> Much of the evidence that has been cited is inconsistent, or derives from studies that have been inadequately controlled, and some is likely to have been distorted by bias against the reporting or publishing of negative results ... In the absence of any unambiguous experimental evidence to suggest that exposure to these electromagnetic fields is likely to be carcinogenic, in the broadest sense of the term, the findings to date

> can be regarded only as sufficient to justify formulating a hypothesis for testing by further investigation. (NRPB, 1992: Introduction)

This report went on to recommend that more emphasis should be placed "on the consolidation of 'positive' findings" to move the field away from discussions of uncertainty and unreplicatable effects (NRPB, 1992: Recommendations for Research).

The late 1990s saw a surge of UK interest in mobile phones as risky objects, potentially contributing to a host of illnesses from headaches, through epilepsy and dementia to brain cancer. Among the contributors to this concern were new and existing interest groups (some of whom had transferred their concerns from earlier worries about microwave ovens, radar and overhead power lines), individuals attributing a range of symptoms to their phone use (Soneryd, 2004) and campaigning (tabloid) news media (Burgess, 2004). With the unprecedented growth in usage of the technology, concerns were raised that current scientific understanding and regulatory protection were insufficient. Newspaper stories frequently drew upon continuing scientific research that claimed to demonstrate evidence of non-thermal effects. These effects were reported as evidence of harm occurring below the safe level determined by the NRPB. In many cases, stories included individual testimony from people who blamed their brain tumors, their sleep loss, their epilepsy or any other illness on mobile phone use or proximity to mobile phone masts. The NRPB, when called upon to respond, tried to defend their guidelines according to the weight of evidence behind them.

At this time, although the NRPB was not a well-known regulatory body, it was the public face of expertise about EMF issues. Its responses to the increasing number of enquiries about mobile phone risks constituted what I have referred to elsewhere as a "discourse of compliance" (Stilgoe, 2005). Questions about the health effects of mobile phones, the adequacy of existing regulatory standards, or relative exposures from different handsets or masts were met with the response that the relevant technologies all complied with guidelines, which were supported by the best available scientific evidence. The NRPB saw its authority resting with its basis in scientific evidence, with its advice being in no way "political." In a 2000 review of scientific advisory guidelines, the Office of Science and Technology (OST) defended the NRPB's approach:

> There has been public concern surrounding the possible health risks from mobile telephones. Responsibility for providing scientific advice to Government on exposure to non-ionising radiation from electromagnetic fields is provided by the National Radiological Protection Board (NRPB); It publishes exposure guidelines based on established thermal effects; However, for both the mobile telecommunications handset and the base station transmitter, it has been suggested that there are other "non-thermal" effects; The scientific evidence for such effects is, at best, ambiguous, but public concerns are as much based on anecdotal evidence; In fact, exposure of the public from mobile base stations is usually thousands of times inside the exposure guidelines. The NRPB is limited to providing advice based on the science only and will not provide precautionary advice. (OST, 2000: Annex A)

The scientific evidence base on which the NRPB's advice rested provided a well-established body of knowledge—what science knew about EMFs and biology before the invention of mobile phones. Scientific advice was therefore ostensibly "science-based" (as opposed to "technology-based"), independent, apolitical and acontextual. But the implicit politics of this position were clearly demonstrated when non-experts realized that the NRPB was not answering the questions it was being asked. The concerned public were not looking for reassurance that mobile phones and base stations complied with guidelines. They were asking questions about the continued adequacy of these guidelines in the face of new

studies, reported widely in the popular press, which seemed to demonstrate novel non-thermal effects.

The NRPB represented scientific uncertainty about non-thermal effects as a solely expert concern. And these uncertainties were given no representation in the numerical standards that emerged from the processes of review, meta-analysis and risk assessment. As one member of AGNIR (the NRPB's Advisory Group on Non-Ionising Radiation) explained to me:

> Above this level is unsafe, below this level is safe. How can you do that on the basis of the literature that exists for non-thermal effects? And secondly, what is the evidence that any of these non-thermal effects might pose a risk to health? The answer is virtually none. So they [the NRPB] knew about them, but they didn't fit into the model to determine finite, numerical standards. (Interview transcript, No. 6)

Public consideration of the level or implication of scientific uncertainty was seen as unwarranted. The NRPB's rhetoric of uncertainty and public engagement revealed a well-established model of the public understanding of science. According to this model, the public were not cognitively equipped to make judgments about the contingencies of scientific knowledge. One independent scientist, who supported the scientific case for safety but criticized the NRPB's lack of public engagement, gave her impression of the need to convince non-experts of the weight of scientific knowledge: "So, when you get a scientific consensus, it's something that the public doesn't understand because they're not part of and nobody tells them, but it's a very, very important thing to have, and it's a very powerful thing" (Interview transcript, No. 27).

A conception of scientific *rationality* was extended to one of public *irrationality*. And the perceived adequacy of scientific understanding left no discursive space for non-expert disagreement. The NRPB's model of science, intended as an authoritative separation from political decision-making, belied a firm construction of who the public were and the desirable extent of their participation in science. The discourse of compliance decreed that non-experts should not be asking certain types of questions and that public concerns as to, for example, the relative harm from high-exposure handsets, were not legitimate.

5. The IEGMP: meeting the public halfway[4]

The NRPB's failure to understand the multidimensionality of public concerns severely dented its credibility. Non-experts increasingly felt that their questions were not being answered and that their claimed symptoms were being unreasonably ignored (often rejected as "anecdotal"). The collapse in public trust in scientific advice, along with the increasing attention of newspapers and interest groups, necessitated the formation of a new, more ostensibly independent body to advise on the health risks of mobile phones. The Independent Expert Group on Mobile Phones (IEGMP), chaired by Sir William Stewart, formerly Chief Scientific Advisor to Margaret Thatcher, was formed late in 1999. Its aim was to consider the issue afresh, emphasizing its independence from the government, industry and the NRPB (who continued to protest *their* independence). The IEGMP acknowledged the trend for increased public participation by including two lay members, holding public meetings and inviting a broad range of activists, scientists and other interested parties to give evidence.

The IEGMP's remit was broadened beyond that of the NRPB, allowing it to "consider present concerns about the possible health effects from the use of mobile phones, base stations

and transmitters" (IEGMP, 2000: 11) while conducting a review of the available science. After the preceding decade's BSE/Creutzfeldt–Jakob disease episode, widely recognized as a scientific advisory disaster, the IEGMP's assessment of the scientific evidence was cautious: "Firstly, the BSE inquiry impacted upon us. Never again will any scientific committee say that there is no risk . . ." (Sir William Stewart, speaking about the IEGMP to the House of Commons Trade and Industry Select Commitee, 13 March 2001).[5]

The science behind mobile phone risk assessment was recontextualized, taking into account the prevalence of mobile phones, their increasing use by children and the rapid growth of base stations. In the cold light of public controversy, the IEGMP's conclusions about the extent and relevance of scientific uncertainty were markedly more cautious than the NRPB's had been. The uncertainties that the NRPB saw as unproblematic were brought to the fore, alongside the IEGMP's recommendation of a precautionary approach to mobile phone use and network expansion. Since the NRPB's previous major review, some new studies had been published reporting cognitive effects on humans exposed to mobile phone radiation. In particular, a study conducted at Bristol University was the first to suggest a cognitive effect of mobile phone radiation on human volunteers (Preece et al., 1999). But this new evidence does not suggest an adequate explanation for the conclusions of the IEGMP. Interviews with IEGMP members suggest that the public context of their work and the decision to be precautionary from the outset changed their assessment of the available science:

> Public perception . . . was taken very seriously, and that was discussed almost at every meeting. (Interview transcript, No. 19—IEGMP member)

> It was simply when we started analysing the results that the uncertainty became more apparent. (Interview transcript, No. 30—IEGMP member)

The group had quickly established that the locus for greatest public antipathy towards mobile phone technology was the rapidly expanding network of base stations. One IEGMP member explained this to me:

> The public meetings were varied in attendance and in the sort of atmosphere, but certainly the common line was that the public was worried, and the public was worried for two reasons. It was worried because it felt that the base stations issue was completely out of their control, and it was worried because it felt that it wasn't given enough information, so people were actually on the whole happy about the mobile phone issue, because at the end of the day, you make a decision about whether you buy one, use one et cetera, and how long you use it for. But if you wake up in the morning and Orange [a UK mobile phone network operator] has just stuck up a base station, there's not a hell of a lot you can do about that. (Interview transcript, No. 19)

Many advisory scientists were initially bemused by concerns expressed about base stations from people who seemed happy to use their mobile phones. Within the discourse of compliance, the fact that base station exposures typically fell orders of magnitude beneath the guidelines[6] had obviated the need for any expert consideration of these concerns. The NRPB's model of the public prescribed reassurance of low exposure as the only course of action. Worries that, for example, the long-term effects of low-level microwave exposure were not included in guideline calculations were not heeded.

The IEGMP's view of uncertainty justified their precautionary approach (or vice versa as Levidow might have it), which recommended that children be discouraged from using their mobile phones, and which called for tightening of the planning rules for mobile phone masts. Such recommendations implied criticism of the NRPB's discourse of

compliance, within which the public could not legitimately decide upon the risks to their children, nor on the possible dangers of mobile phone masts. But the IEGMP also explicitly criticized the NRPB's management of public concern (while taking care not to undermine its scientific work):

> Whilst there is no criticism of its science, we recommend that NRPB gives greater priority to the execution of a more open approach to issues of public concern such as mobile phone technology and that it is proactive rather than reactive in its approach. (IEGMP, 2000: paragraph 1.67)

The IEGMP continued building bridges towards the public with its recommendation of further research, looking into areas qualitatively different from those considered important in previous decades:

> We recommend that a substantial research programme should operate under the aegis of a demonstrably independent panel. The aim should be to develop a programme of research related to health aspects of mobile phones and associated technologies . . . In developing a research agenda the peer-reviewed scientific literature, non-peer reviewed papers and anecdotal evidence should be taken into account. (IEGMP, 2000: paragraph 1.58)

By 2000, the term "anecdotal evidence" had been politicized as a microcosm of the illnesses, concerns, arguments and frustrations that members of the public had attributed to mobile phones and their masts. The inclusion of the term in the recommendation therefore signaled the group's intention to fund research that the public would consider relevant. This research would be administered by the Mobile Telephones Health Research (MTHR) program committee, an expert group containing many of the members of the original IEGMP.

The MTHR program held public meetings to discuss its research priorities. Experts and the public debated what the public were *really* concerned about and how research would assuage their fears. After its third call for proposals, the MTHR committee funded research in areas that it felt would address public concern. Three studies were funded to look at "Electrical Hypersensitivity," a contested illness where sufferers claim to experience debilitating symptoms with exposure to weak electromagnetic fields (Soneryd, 2004). One of these aimed to test the relationship between base station (rather than mobile phone) exposure and symptoms. In addition, a case-control study was funded to study the possible connection between childhood cancers and base station proximity.[7] In an MTHR press release, the chair of the program committee, Lawrie Challis, said, "I am very pleased that the MTHR programme is responding in this way to public concern about possible health effects from base stations."[8] Perhaps most tellingly, the study that drained the last of the committee's funds was a psychosocial analysis of risk responses to precautionary recommendations—an explicit scientization of "public concern".[9]

The recommendations of the IEGMP and (though less prominently) the work of the MTHR program have answered some of the criticisms initially directed at the NRPB's style of scientific advice. But the precautionary approach to mobile phone risks, and its accompanying participatory rhetoric, has attracted a good deal of criticism from scientists, social scientists and industry. In a recent book, sociologist Adam Burgess criticizes such precaution as a policy motivated by politics rather than science (Burgess, 2004). He suggests that the call for further research is unwarranted, because of the impossibility of harm from mobile phones. A similar sentiment has been expressed by scientists, who feel that precaution, by embracing public concern and highlighting uncertainty, undermines the

available scientific evidence (e.g. Foster et al., 2000). One esteemed senior scientist, clearly with a firm impression of who The Public were, suggested to me that precautionary policies were counterproductive in dealing with public concern because they were likely to spread "alarm and despondency" (Interview transcript, No. 29). Such comments suggest an assumed adequacy of the state of orthodox scientific understanding. But, following the analysis I have presented here, we can also read debates about precautionary policies in terms of their implicit models of the public. Critics of EMF precaution tend to see The Public as passive and deficient in their knowledge and capacity for understanding uncertainty.

Such disputes bring to light the tension between technocracy and democracy experienced by advisory scientists, whose decisions must be at once scientifically authoritative and politically credible (Jasanoff, 1990). In his report and in subsequent press interviews, Sir William Stewart made a number of recommendations that seemed to his critics more "political" than "scientific." In particular, his recommendation that children should be discouraged from using mobile phones was seen by many scientists as unsupported by the available evidence. Sir William was asked to defend his recommendations to the House of Commons Trade and Industry Select Committee, who began an investigation of the mobile phone mast planning regime in 2001. The committee asked about the recommendation that schools should be considered particularly sensitive sites for new masts:

> Q: What about churches because they are used for childcare, or hospitals? Do you think that there should be national guidelines criteria for site selection?
>
> A: My point is that I do not care much whether it is a church or a football stadium, so long as they meet the guidelines. Those are the guidelines that have been nationally accepted at the present time. We should adhere to those until evidence becomes available that they should be higher or lower. (Sir William Stewart, Minutes of Evidence to the House of Commons Trade and Industry Select Committee, 13 March 2001)

In the light of the Stewart report's earlier rejection of the discourse of compliance, this answer seems inconsistent. But it illustrates the difficulties of maintaining authority while defending scientific advice that explicitly addresses issues of public, as well as scientific, concern. The tactic that is revealed is interesting. When the Stewart report is challenged by scientists who claim it did not represent the true state of the science, the explanation most often given is that it was "flavored" by the political elements of public concern, distrust and the specter of BSE. But when the Stewart report is itself challenged on the grounds of the myriad policy and advisory questions that it has opened up to challenge, the easiest retreat is to appeal to rationality, arguing that it is the guidelines, supported by expertise, which provide protection (as above).[10] A tension emerges, which contributes to the discursive inconsistency, between *science* and *advice*, between *rationality* and *pragmatism* and between *public reassurance* and *public engagement*.

At a local level, such inconsistencies have led to a fragmentation of planning controls, with confusion as to whether local authorities are allowed to (or have the expertise to) take into account health effects when making planning decisions. National guidance, according to one civil servant, does take into account public health concerns: "Health effects can be taken into consideration, but they're met by the requirement of compliance with . . . exposure guidelines" (Interview transcript, No. 11). The public being constructed here are a public who seek reassurance of compliance which, as I mentioned above and have described elsewhere (Stilgoe, 2005), misses the point. This response is answering a question that concerned sections of the public are not asking. The implicit model of public concern does

not account for the complexities of public engagement with science. Public concerns are multidimensional, subject to change and difficult to nail down with recourse to simple models of public action.

Part of the confusion seen in the wake of the Stewart report originates with the report's novel appreciation that "The Public" can never refer to a single group (non-scientists) with homogeneous interests. Sir William appreciated that, for his report to understand (and maintain a degree of control over) public concern, different publics needed to be seen in different ways. Most of the UK population were consumers of mobile phones, only marginally interested in the science behind a beloved technology. But some were seriously concerned and engaged with the science of mobile phone risk on a number of levels. This separation of general and concerned publics is implicit in the Stewart report's reading of the science and presentation of its recommendations. And while this new model of the public opened up new and difficult areas of debate, it went some way towards regaining control of the public context of uncertainty about the issue.

6. Conclusion

It should come as no surprise that new technologies bring new risks, or new doubts about unforeseen consequences. The public concern that we see around these innovations can tell us a great deal about the relationship between experts and the public. The pattern of experts telling non-experts what "correct" areas of concern are is an extension of a deficit model of science and society, and is no longer sufficient. Public participation is now recognized as a necessary part of the process of scientific decision-making. Increasingly, therefore, there is pressure on experts to identify areas and extents of public concern.

For the majority of mobile phone users, the individual benefits negated the question of risk. For the small percentage of users who reported symptoms when making calls, the mitigation of risk, even if this risk could not be explained by experts, was straightforward. However, when the mobile phones health controversy (and rapid network growth) made base stations more visible, public concern became more complicated. With base stations, public discontent was complicated by the skewed distribution of (possible) risk towards people who lived nearby. The benefits of a mobile phone mast are general (increased network coverage) rather than specific to those people burdened with the technology.

I have tried in this paper not to draw an accurate picture of what public concern about mobile phones and their masts looks like, nor what the extent of scientific uncertainty about mobile phones is. "Public concern" is not a fixed thing. It is dynamic and subject to a great deal of interpretative flexibility. Public concern is multidimensional and dependent upon a relationship of trust or distrust in expertise. As with other issues involving science, public opinion about the risks of mobile phones can be expected to be complex and ambivalent: concerns about health are likely to be tied up with opinions about mast siting, children's usage and the necessity of ever-developing networks. As we have seen in this paper, experts, in doing "public science," must interpret evidence and uncertainty, making recommendations of precaution or areas of future research. But they are also forced to contextualize their work and realize its public dimension. I have argued that, in doing so, they legitimize or reject areas of concern and instrumentally construct their publics. This paper has narrated the move between two styles of public science which suggest subtly different constructions of both scientific uncertainty and public concern.

The NRPB, eager not to be construed as doing "politics" (cf. Jasanoff, 1990), strove to maintain scientific uncertainty firmly in the domain of expertise. This had the effect of

preventing public engagement with science (Stilgoe, 2005). The public were viewed as homogeneous, cognitively deficient and passive, demanding reassurance rather than engagement. The NRPB lost credibility and the trust of the concerned public when the public began questioning their own constructed role, asking questions about science that the NRPB was not prepared to answer. The NRPB, with their commitment to science-based advice, was unable to address this credibility problem. The representatives of science claimed there was a strong consensus over the (lack of) health effects of mobile phones, so it was easy to reject claims from non-experts as "irrational." "Public concern" was thus constructed as a formless mass of unfounded fears, as nothing more than *the opposite of expertise*. Addressing this concern while claiming to remain "scientific" was impossible. Without a fairly radical change of philosophy, the NRPB could not solve its own credibility trap.

The creation of the Independent Expert Group on Mobile Phones allowed for a new approach to public engagement in the science of mobile phone risk. The IEGMP's precautionary approach included a more explicit consideration of scientific uncertainty, and particularly the types of uncertainty that had emerged as publicly relevant. But the NRPB's previously scientistic framing of issues such as base station exposure meant that the IEGMP's work was seen as more public—both "political" and "scientific." The IEGMP explicitly addressed the public concerns that they had identified, which justified a degree of reassurance that, for example, the rate of exposure from base stations was typically orders of magnitude lower than from handsets. But the Stewart report also identified areas of uncertainty about long-term effects and genetic variation in susceptibility that responded to some of the new questions being asked by concerned subgroups of non-experts. The IEGMP situated scientific advice within the politics of technology, the politics of public disenchantment and the politics of previous advisory shortcomings (such as the BSE debacle). This overlap between areas of public concern and areas of scientific concern continues, at the time of writing, with the MTHR program, which reminds non-experts that, although the jury is officially "out" on mobile phone health risks, we know who the jury are and when they might be coming back.

It is now clear that the UK expertise must pay attention to the maxim of public engagement. In this new climate of reflexive expertise, with advisory scientists considering the credibility of knowledge along with its authority, we must develop a more sophisticated appreciation of what is happening to "public concern" when it is identified, legitimized and co-opted. This paper has supported the move towards considering how experts *construct their publics* as part of the process of doing public science. Bruno Latour has explained how science and technology construct their publics (just as sociological texts construct their readers). Problems occur when publics feel that they have not been fairly represented (as when a reader feels that she is not the person the text expects her to be) (Latour, 1988: 307).

The NRPB's problems of credibility can be explained with reference to a public no longer behaving according to the model to which the NRPB subscribed. Interested publics realized they were being denied the discursive space to discuss salient aspects of mobile phone risk. As Andrew Barry has described, the attempt to cordon off areas as "apolitical" will only lead to new sites of political contestation (Barry, 2001: ch. 9). In the mobile phones case, uncertainties about long-term health effects or the framing assumptions behind guidelines were the subject of political battles despite previous scientific efforts to emphasize their apolitical credentials. The IEGMP attempted to address some of these areas, but "public concern" remained slippery and resistant to expert codification. In the case of mobile phone risks, non-experts could be seen strongly resisting expert attempts to co-opt their concerns.

The public meetings of the MTHR committee have been characterized by competing definitions of public concern. Experts have targeted their research to address some areas of overlap between areas of scientific and public interest. But non-experts continue to argue that existing research is not *really* addressing public concerns. "Public concern" is seen by some as a smokescreen behind which the existing scientific consensus can be reinforced. Most starkly, the recent funding of "psychosocial" studies by the MTHR committee has been criticized as a way of continuing to avoid conducting studies addressing "real" public concerns.[11] One caution we can draw from this is that advisory scientists should not believe that public concerns can be taken into account in a neutral way, without creating new areas for dissent.

Although it is impossible to judge conclusively while the controversy is ongoing, my analysis suggests that the IEGMP and the MTHR committee between them have regained a degree of *social* control of uncertainty (Wynne, 1987).[12] The enrolment of a body of public concern has the effect of marginalizing and delegitimizing more fringe interests (cf. Michael and Birke, 1994). The main UK mobile phone mast protest groups make it clear that they are not Luddites. They are not against masts or mobile phone networks per se[13]—they merely want more sensible siting of base stations. Although some individuals involved in the controversy privately doubt the need for a third generation of mobile phone networks (3G), the public debate currently seems more constructive.

This paper joins a movement towards seeing scientific controversies as featuring "co-produced" scientific and social order (Jasanoff, 2004). Specifically, the narrative of this paper demonstrates that states of scientific uncertainty are produced along with public engagement in science. This paper has problematized both elements as slippery and difficult to nail down. Just as attempts to resolve salient areas of scientific uncertainty will open up new contested domains, so attempts to represent public concern will be questioned by the public. Expert responses to questions of scientific uncertainty are necessarily responses to questions of engagement with public concern. In public science controversies, evidence becomes politicized, as seen clearly in the case of the recent UK controversy over the measles, mumps and rubella vaccine (see Moore, 2003). The move to reinterpret evidence, and call for more diverse knowledge production is therefore a democratic one, changing the bounds for public engagement. But advisory scientists should not convince themselves that public concern is a fixed quantity. The mobile phone industry, who increasingly try to gauge what level of public concern is "out there,"[14] are contributing to a model of public action that represents only part of the public context of mobile phone technology. Changing contexts and new technologies will offer new challenges to risk management. Although the success of 3G mobile phones will most likely be decided by price, desirability, usability and the extent of market saturation, experts (and industry) must be aware of the possibility of new doubts, new concerns and new risks.

In supporting a move towards a more nuanced co-production picture of science and society, I challenge the separation of risk into "scientific" and "social" domains (of which both scientists and social scientists are guilty). "Risk" is neither "scientific" nor "social." It is the (co-)product of representations of both nature and society. In the mobile phones case, there is nothing that clearly tells us how to separate risk "assessment" from risk "perception." What we do see, at least as it stands, is the attempted management of a risk issue by a group of reflexive experts who seem to appreciate the necessity of broader appreciation of uncertainty and non-expert engagement.

The important demand on experts in this area is not the authority of their advice, nor the sensitivity with which they can identify what the public are concerned about. Experts need to develop the flexibility to reflexively adapt to changing contexts of public

engagement, with the realization that expert action crucially impacts upon public concerns. This paper has contributed to an understanding of public engagement with science that questions the applicability of rigidly designed participatory instruments. Instead, the challenge for experts is to remain aware of the possibility of less formal engagement with publics around issues of concern.

Postscript

I should add that, on 31 March 2004, the NRPB (now chaired by Sir William Stewart) recommended the adoption of lower (international) guidelines for EMF exposure, prompted by the recommendations of the Stewart report. For the first time, the NRPB explicitly acknowledged both the concerns of the public and the applicability of a precautionary approach to EMF regulation (NRPB, 2004). Of course, it remains to be seen whether the NRPB can manage the issue successfully now the responsibility is once again theirs.

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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), found that 43 percent of daily users in the UK were particularly concerned about the potential risks from mobile phones (MORI, 1999).

2 In regulatory circles, a dichotomy is often drawn between risk assessment, which is seen as scientific and neutral, and risk management, which deals with questions of acceptability, perception and policy. This paper makes no such distinction, and serves to support the argument that value judgments are integral to all parts of the risk spectrum. (For a recent explanation of the policy implications of such a distinction in a public dispute, see Busch et al. (2004).)

3 Wynne has identified four areas of scientific "non-knowledge"—risk, uncertainty, ignorance and indeterminacy (Wynne, 1992). Of these, science is least able to deal with the areas of ignorance and indeterminacy. These areas might often be represented as scientifically definable and less-problematic "risks" or "uncertainties" (Shackley and Wynne, 1996). For the purposes of this paper, I have adopted a more constructivist perspective, put aside this typology and used the word "uncertainty" to describe any representation of scientific non-knowledge.

4 Thanks are due to Jerry Ravetz for this phrase, which nicely encapsulates expert/public negotiation and the subsequent overlapping of scientific and public concerns.

5 It should be noted that Sir William Stewart was chief scientific advisor to the Conservative Government from 1990 to 1995, although he told the Phillips inquiry into the handling of the BSE crisis that his direct involvement in the BSE saga had been "negligible" (The BSE Inquiry/Statement No. 187, Sir William Stewart, page 4, URL: http://www.bseinquiry.gov.uk/files/ws/s187.pdf (accessed 20 August 2003)).

6 As might be expected, this "fact" is open to contestation. Some commentators have argued that simplistic attempts at calculating base station exposures ignore radiation "hotspots," points of constructive interference which might approach or even exceed international guideline levels.

7 At the time of writing, all of these studies are ongoing. It remains to be seen how their results will be interpreted by concerned publics.

8 MTHR press release, 22 January 2004, URL: www.mthr.org.uk/press/PressReleaseP5.htm (accessed 9 June 2004).

9 The project, called "Communicating Uncertainty: Mobile Telecommunication Health Risks" is run by Dr. Julie Barnett at the University of Surrey. It is "designed to explore what people understand about the uncertain risks

associated with mobile phone handsets and base stations." URL: http://www.mthr.org.uk/research_projects/CommunicatingUncertaintyMobileTelecommunicationHealthRisks.htm (accessed 10 July 2005).

10 I am reminded of Bruno Latour's motto: "When controversies flare up the literature become technical" (Latour, 1987: 30).

11 Alasdair Philips, for example, recently criticized the MTHR program for attempting to manage public concern (Powerwatch web site, November 2003, URL: www.powerwatch.org.uk (accessed 23 November 2003)).

12 In saying this, I am in marked disagreement with Burgess (2004), who argues that the Stewart report's endorsement of precaution only compounded mobile phone fears. The recommendation must therefore be for more research looking at the effect of expert claims of uncertainty on perceptions of risk.

13 For example, Mast Action UK, giving evidence to the All Party Group on Mobile Phones, 11 May 2004.

14 UK network operators, via the Mobile Operators' Association (MOA), have formalized "Ten commitments to best siting practice" and a "Traffic light rating model for public consultation," the aim being to reduce the surprise of public protest by understanding the likelihood of dissent (see www.mobilemastinfo.com and Wardman, 2004).

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