Knowing the Unknown: issues in the public perceptions of risk

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Introduction

People's awareness of medical, scientific and technological developments, and the influence of that knowledge on their attitudes and behaviour, is of continuing relevance for medical sociology and the broader understanding of the sociology of science. Public interest in environmental pollution, genetically modified food, the human genome and new reproductive technologies, for example, raise profound questions about state policy in those areas but also indicate the salience of the concept of the risk society. Among the dominant and recurrent themes for debate and research are the nature of public perceptions of risk and the connected questions of the relationship between 'lay' beliefs and expert knowledge, and aspects of public trust in scientists and regulatory agencies. These themes and questions are of enduring and widespread interest but are especially significant in discussions about emerging technologies and scientific innovations - developments which by definition are unknown or unfamiliar outside of relatively small groups of experts/scientists. This paper will consider some key aspects of these questions in relation to Hydrogen as a new large-scale source of energy.

First, a very brief outline of the current development of Hydrogen energy will be presented. Next, the paper will summarise the major implications deriving from the debate about 'lay' beliefs about health and illness. These will then be juxtaposed against arguments about the public understanding of science and public perceptions of risk. The paper will relate this (very briefly) to the discussion concerning constructivist and realist accounts of scientific knowledge and the risk society. Finally, some consideration will be given to methodological questions about investigating public perceptions of, and

attitudes to, the 'unknown' technology of a future Hydrogen economy/society.

Hydrogen energy and the Hydrogen economy/society

Global warming, environmental pollution, the rapid consumption of fossil fuels, and strategic instability among major oil producers have forced western governments and industries to rethink the future of energy supplies. Environmental social movements have added to the demands for 'green' solutions to the energy problem, and especially for sustainable or renewable energy. It is in this context that the revolutionary potential of Hydrogen energy is being advocated by a wide array of different interest groups. Environmentalists and energy companies and governments have all become increasingly interested in developing Hydrogen as a replacement for energy derived from fossil fuels. Hydrogen is the most abundant element in the cosmos, and one of the most important elements in the chemistry of energy-producing materials (Groachal and Edwards, 2004). Hydrogen can be stored as a gas or liquid, or used in chemical form; usually it has to be stored under great pressure and at very low temperatures. It has become labelled as a 'utopian' or 'forever' fuel, as it can be continually produced by splitting up water (into hydrogen and oxygen) or by using electricity from solar cells or wind and wave turbines; it can also be produced from biomass and some industrial waste. Feature articles in New Scientist (16 August 2003) noted that Hydrogen in fuel cells can store energy and generate electricity very efficiently. Hydrogen has been characterised as being clean, efficient, non-polluting, non-global warming and renewable. The European Union has recently invested 2 billion Euro for H research over the next five years; in the USA, Bush has invested 1.7 billion dollars. Hydrogen

based fuel cells are already in use in some motor vehicles (cars and buses) produced by BMW, Daimler-Chrysler, Honda, Toyota; there are also public buses running on H fuel cells in Amsterdam, Bonn, Chicago, Vancouver - and one experimentally started recently in London. Advocates of H fuel cells predict more applications in localised power supply units, and possibly in computer laptops and mobile phones. It is possible that the large-scale substitution of Hydrogen for carbon- based energy would reduce health inequalities (Bellaby, 2003). 'Evangelists' such as Jeremy Rifkin (2002) have popularised the notion of a Hydrogen Economy to replace the carbon- or fossil-fuel based economy. For Rifkin, Hydrogen energy has the potential to reconfigure the entire economy and social structure, in ways comparable to the invention of the printing press or more recently the World Wide Web. Hydrogen powered fuel cells could enable locally distributed-generation of electricity, with each household, factory or organisation having its own mini power station. This, according to Rifkin, offers the possibility of radically democratising energy, and fundamentally changing power relations between producers and consumers.

The major problems with the development of Hydrogen energy identified by most commentators include: the enormous infrastructural investments required for production, generation, storage and distribution; the technological feasibility and costs of fuel cells; the possible safety hazards of storing hydrogen in gas or liquid form; and the fact that although Hydrogen may eventually be produced from renewable sources (biomass, solar, wind, wave) currently most commercially produced Hydrogen is derived from steam-reforming using natural gas or other non-renewable energy sources (see Hodson and Marvin, 2004; Randerson, 2004). Some scientists have warned that there are potential dangers from leakages of hydrogen into the atmosphere and

affecting the ozone layer (Anathaswamy, 2003, New Scientist, 15 Nov, 6-7). Others have pointed out that undetected leaks pose wide public safety risks, with potentially huge liabilities (Moy, 2003). Most of the debate so far has been preoccupied with economic and technological questions of feasibility - it is "inherently expensive to transport, store and distribute" (Keith and Farrell, 2003, 315-6). But it has also been recognised that any large-scale transition to an Hydrogen economy will require greater public awareness of Hydrogen energy and its applications. Those interests promoting Hydrogen acknowledge that to gain popular acceptance necessitates greater public understanding of the risks and benefits (see Bellaby and Flynn, 2004).

The present situation is then, dynamic and fast-changing: government and sections of the private sector (motor vehicle manufacturers, energy producers) are investing substantially in research and development, while some 'Green' parties and environmental movements anticipate that Hydrogen may facilitate a more ecologically-friendly and sustainable (and according to Rifkin, potentially decentralised and democratic) energy source. In the UK, the EPSRC programme on Hydrogen is investigating the science and technology of the production, storage and transmission of Hydrogen energy, but from its inception it has acknowledged that this research must be accompanied by parallel studies of the social and economic implications. One of the key dimensions of this work is people's awareness of, and attitudes towards, different types and uses of hydrogen energy; connected to it is the issue of appropriate regulatory mechanisms. This paper is a preliminary attempt to review some of the relevant literatures which can be applied to such questions. One crucial dimension of this is the public perception of risk. There is an enormous body of literature connected with this in the social studies of science and technology, and it is instructive to compare this with

some of the debates about 'lay' knowledge in health. The following section therefore begins to consider this by discussing (very briefly and highly selectively) the importance of 'lay' beliefs in health and illness.

Lay Beliefs or Lay Knowledge?

In medical sociology, it is now almost axiomatic that in trying to explain and understand the experience of health and illness it is essential to give prominence to 'lay' beliefs or 'subjective' knowledge of disease and wellbeing. However, this emphasis is relatively recent; of course to a large extent it was also regarded as a challenge to the orthodox biomedical and epidemiological paradigm (Nettleton, 1995). As (the late) Meg Stacey (1994) pointed out, conventionally, many medical practitioners regarded patients' knowledge and understanding of their bodies and illness as erroneous or deficient - and the source of non-compliance with doctors' advice, failure to adhere to prescriptions and treatment. Stacey also stressed that peoples' "experiential knowledge" was nonetheless vital, although different from medical 'expert' knowledge. Similarly, Phillimore and Mofatt (1994) observed in their study of environmental pollution (in Teesside and Tyneside) there was a hierarchy of credibility in which local residents' daily experience and knowledge (and their perception of risks) was discounted by epidemiologists, but was nonetheless instructive and relevant. Williams and Popay in the same volume (1994a) highlighted the contentious nature of different knowledge-claims and discourses about health, illustrating the disagreements between medical scientists and local communities in a water pollution incident. Kelleher et al (1994) pointed out that such disagreements were increasing as medical hegemony was disputed through the rise of patient self-help

groups and litigation for negligence; lay knowledge also gained some support as part of the movement to incorporate 'local voices' in NHS service planning.

Again Williams and Popay (1994b) noted that lay knowledge represents a challenge to experts' claimed authority and objectivity; conversely, orthodox public health and medicine regarded lay beliefs as irrational and unreliable. However, Williams and Popay argued that lay beliefs are internally consistent and coherent, and provide meaningful accounts of people's daily experience of health, illness and the environment, and for that reason must be acknowledged as valid discourses about public health risks and hazards. Such a 'popular epidemiology' comprises a potential threat to the trust in (medical) experts.

Potential conflicts between patients' understandings and medical knowledge were seen as intensifying in the management of risks in, for example, HIV (Bloor 1995; Grinyer,1995). What also emerged was that even when the 'health beliefs model' was accorded some utility, the cognitive psychology approach to risk perception on which it was premissed, assumed that risks existed objectively and independent of their cultural and social context (Gabe, 1995). In contrast, anthropological (cf Mary Douglas) and sociological accounts of risk perception gave greater prominence to the active social construction of risk in particular cultural and institutional contexts.

In addition to this divergence between constructivist and realist approaches to risk (discussed further below) it is worth remarking on the tension within contemporary British medical sociology between those who advocate the intrinsic validity of so-called 'lay-expert' knowledge (Popay and Williams, 1996), as against the variable relevance of

lay beliefs (Prior, 2003). There is a fundamental disagreement between those who argue that "lay people acquire an 'expert' body of knowledge, different from but equal to that of professionals in the public health field" (Popay and Williams, 1996, 760) and those who insist that the notion of a 'lay expert' is an oxymoron, because while people obviously do have beliefs about and experience of illness, that 'knowledge' can be in error - "lay people are not experts" (Prior, 2003, 45).

Thus we arrive at a position in which lay beliefs have been given greater prominence in broader explanations of health and illness, but there is continuing dispute about their epistemological status, as well as uncertainty about how such beliefs/knowledge actually affect behaviour. There is also a conventional view that lay beliefs and expert (medical scientific) knowledge are inherently different and potentially divergent. The next section explores some parallels in the analysis of the public understanding of science more generally, and then some comparisons will be drawn.

Public Perceptions of Science and Technology

Numerous writers in the sociology of science and technology have observed that the orthodox or conventional assumption among most scientists and policymakers is that the lay public is scientifically illiterate and must be educated in order to appreciate the positive value of scientific advance and technological change. What has been termed the 'Public Understanding of Science' [PUS] model (Irwin and Wynne, 1996) is based on the assumption that science provides objective knowledge which citizens are often unable to comprehend, so strategies are required to inform them about 'the facts'. Alan Irwin and Brian Wynne discuss the famous Royal Society report (1985) which portrays a benign, value-free science, which - if only better understood by the public - could

make valuable contributions to society. Irwin and Wynne (among others) present evidence and analysis which shows how scientific knowledge is socially-constructed, context-dependent, contested and problematic. Irwin (2001) argues further that the public understanding model is too crude and simplistic on several counts, not least is the fact that 'the public' is highly differentiated, and people's perceptions of environmental issues or risks are mediated by numerous factors. Individuals and groups simply do not 'respond' to facts presented by experts; they interpret and frame them in terms of their own experience and particular interests. Irwin and Michael (2003) also argue that the dominant 'deficit model' - i.e. that there is a high level of public ignorance about scientific knowledge which can be remedied by better communication of information - is invalid and misplaced.

This seems to have been partly recognised by some major science and technology stakeholders, especially in the wake of widespread disquiet about BSE and Genetically Modified Organisms. Thus for example the Royal Commission on Environmental Pollution (1998) accepted that risk and uncertainty in science should be debated, and public values addressed by scientists and technologists. Similarly, the House of Lords Select Committee on Science and Technology (2000) recommended a shift away from a 'public understanding of science' model towards a 'science and society dialogue' (Irwin, 2001;Irwin and Michael, 2003). The Office for Science and Technology and Wellcome Trust published a report in 2000 (OST & Wellcome Trust, 2001) noting that there were important considerations about gaining public confidence and trust, and that the 'deficit' model should be replaced by a two-way dialogue or 'engagement model' for science communication. Most recently, the Royal Society and Royal Academy of Engineering report on nanoscience and nanotechnologies (Royal Society and RAE,

2004) highlighted the necessity to include ‘stakeholder and public dialogue’, to achieve greater openness and transparency about risks and uncertainties in science and technology. More broadly, the editor of the Journal Public Understanding of Science, in an editorial celebrating the journal's first decade, observed that there is a multitude of publics:

"who make meaning of science only in specific local contexts, often dealing with uncertain knowledge, policy and (political) decisions, and the enduring tensions between 'expert' and 'lay' perspectives" (Lewenstein, 2002, 2).

So, there has been significant change in the orientation among some science policy stakeholders, to recognise the importance of public awareness and involvement in debates about scientific and technological innovation. There is, though, as Irwin and Michael (2003) note, a lingering 'technocratic' presumption that the primary task is persuasion, to gain social acceptability and to enhance trust in experts. There is also, it seems, a continuing assumption that scientific knowledge and issues are discrete technical matters which simply require improved methods of communication. The notion of what in health policy has been referred to as 'popular epidemiology', and what in science and technology has been referred to as 'citizen science' (Irwin, 1995) have so far not resulted in much practical change in the organisation of public debate or governance of science. In each case, the questions arise about how one investigates public general awareness and knowledge of complex medical, scientific and technological issues; how to assess people's beliefs about and attitudes towards risk in particular; and how to account for any divergence between 'real' as against 'perceived' risks where scientific knowledge itself may be uncertain (see Kallerud and Ramberg,

2002).

This of course necessarily entails some consideration of arguments about 'realist' and constructivist' approaches to risk. Space (and time) obviously prevents a detailed discussion here (but see Boyne, 2003; Lupton, 1999; Tulloch and Lupton, 2003; Wilkinson,2001). It is worth noting that Beck has declared himself both a realist and a constructivist, and also argues that these are not either/or options (Beck, 2000; Szerszynski et al, 1996). Beck (2000, 219) emphasised that risks are simultaneously real and constituted by social construction and individual perception. Environmental (and health) risks - even if they are scientifically known, which frequently they are not - are comprehended differentially and acted upon in heterogeneous ways. Again as Wynne (1996a; 1996b) and Irwin (2001) have shown from various studies, ostensible or putative risks may not in themselves be recognised or given importance by people in local communities, or they may be given lower priority in comparison with other issues. Different groups select and interpret environmental concerns in different ways, and it is in this sense that risk can be regarded as a 'co-construction' and as partially an outcome of social and cultural processes not just individual cognition. As Adam and van Loon (2000, 2) comment:

> "One cannot therefore observe a risk as a thing-out-there
> - risks are necessarily constructed. But they are not
> constructed through voluntary imagination - we are not free
> to construct risks as we please".

This intermediate - or as Beck (1996) himself terms it, 'pragmatic' - position is taken

here. It seems appropriate, necessary, and almost inescapable when considering public awareness of risks and their inherent uncertainty. How then can this be applied in the context of environmental risk perception, and how might it be developed to investigate attitudes towards Hydrogen energy?

Environmental risk perception and Uncertainty

There is a vast and ever-growing multi-disciplinary literature surrounding risk analysis and risk management which cannot be summarised here. What can be highlighted, nonetheless, is that the predominant methodological approach until recently has been highly positivist and quantitative. It is also evident that research on public perceptions has been dominated by an individualistic focus based on cognitive psychology and experimental techniques, as well as the 'rational actor paradigm' (Renn et al, 2000; Scherer and Cho, 2003). It is recognised that pioneering work was done (most notably by Paul Slovic and colleagues) from the 1970s onwards, using psychometric methods to identify - on different rating scales - how people defined and assessed various risks (Slovic, 2000). The basic assumption underlying much of this body of work is that atomized individuals make choices, decisions, evaluations, judgements on the basis of objective information about risk. An implicit assumption is that people's subjective perceptions are often 'mistaken' or incomplete (Lion et al, 2002; Scherer and Cho, 2003).

Some common have patterns emerged from this work, however. For example - laypeople and technical experts differed significantly in their views about the risks and benefits of hazards, but among the public technologies perceived as beneficial or useful

were associated with less risk (Siegrist and Cvetkovich, 2000); there was (is) a very wide disparity between the views of scientific experts and members of the public about the risks associated with nuclear power, radioactive waste and some other technologies (Kunreuther, 2002); those hazards about which people had little knowledge or dreaded most were perceived as the most risky (Kunreuther, 2002).

In other studies of perceptions about potentially harmful risks, the seriousness of risks has been shown to be affected by numerous 'contextual' variables - including whether human fatalities or material damage is anticipated; whether potential catastrophe is imagined; respondents' familiarity with and extent of influence or control over events; and the degree of trust in regulatory agencies (Klinke and Renn, 2002). There is also a very close linkage between perceptions of the degree of scientific uncertainty and the willingness of laypeople to trust scientists, government, industry and regulators (Siegrist and Cvetkovich, 2000; Wildavsky and Dake, 1990).

The ‘problem’ of even acknowledging uncertainty clearly influences public acceptance of science and trust in experts. Johnson (2003) has noted that it has been a longstanding problem in risk management to convey uncertainty in environmental risk estimates to lay audiences. Among those surveyed, differences in such risk-estimates were often ascribed to perceived self-interest among the experts themselves, rather than inherent scientific uncertainty. This reinforced previous findings by Johnson and Slovic (1998) that when presented with varying estimates of risk by scientific experts, members of the public were 'concerned and distrustful'. In this [US] study, residents in one city were presented with a range of different risk estimates about a hypothetical

case of a chemical in drinking water. The researchers found that 'low' risk estimates were regarded by laypeople as 'preliminary' and/or were distrusted. Johnson and Slovic concluded that it is difficult to present uncertainty in environmental health estimates in ways that inform rather than confuse or even outrage the public! (Johnson and Slovic, 1998).

Similarly, recent British research has revealed some comparable patterns. Frewer et al (2002), in the aftermath of BSE, carried out a large-scale questionnaire survey of public preferences for informed choice about food safety under conditions of risk and uncertainty. The sample were asked to categorise different statements about uncertainty. It was found that respondents recognised various types of uncertainty and expressed different views about their acceptability. For example, uncertainty connected with the science was more acceptable than uncertainty due to lack of government action. Frewer at al (2002, 370) conclude: "Public reactions to uncertainty associated with specific hazards is dependent on other psychologically meaningful dimensions of those hazards, such as perceived controllability, benefits, catastrophic potential, and so forth". Alison Shaw's work on lay understandings of Genetically Modified food (using qualitative methods) also shows that communicating risk in conditions of scientific uncertainty is problematic, and that consumers' were sceptical about trusting the experts. She found that credibility of and trust in scientists was linked with perceived uncertainty. Interviewees' lay understandings of GM food were based on little knowledge; those who were most informed were also the most opposed to GM food; there was fatalism about their ability to influence policy; and distrust of industry's and scientists' capacity to manage risks effectively and responsibly (Shaw, 2002).

Siegrist and Cvetcovich (2000) [in a small-scale questionnaire survey in the USA] found that in the absence of knowledge about risks and benefits, laypeople relied upon social trust. However, in larger-scale quantitative study of the nuclear industry in Sweden, Sjoberg (2001) demonstrated that: laypeople had more concerns about *unknown* effects; that the unknown was expected to be 'bad'; and that the public was more sceptical about the completeness of experts' knowledge that the experts themselves were. Sjoberg illustrates that people may perceive spokespersons for the nuclear industry as competent and honest, yet still disagree with their recommendations that risks are negligible, because people believe that experts do not have complete or certain knowledge. As Sjoberg (2001, 197) comments:

> "The most important predictor of perceived risk turned out
> to be beliefs about the likelihood that there might be
> effects that are as yet unknown".

This core question about scientific uncertainty and the limits of providing 'information' to an 'ignorant' public has now become accepted as both a theoretical and practical challenge. This is clearly reflected in Grove-White and his Lancaster colleagues' study of the communication of information about GM crops and food (Grove-White et al, 2000). In their qualitative study of experts and specialists and members of the public (focus groups) they showed how the industry and government specialists assumed that information communicates what is known in a positive sense, but the communication of 'unknowns' - questions of scientific uncertainty - were not seen as their responsibility. Laypeople varied in their attitudes to different technologies, were suspicious of GM foods and the motives of those producing them, and based their trust not on the information supplied but on their own previous experience of relevant producers or

regulators as well as 'trusted 'others' in their own networks. Most people believed that they had little control over the development of new technology, and were also concerned about the unknown long-term effects of such technology.

Again from the perspective of the public, the British Social Attitudes Survey has shown that people's views about the environment, risk and science were 'contradictory, suggesting a high degree of confusion and inconsistency' (Christie and Jarvis, 2002,135). Moreover, respondents' environmental concerns were not translated into action. Christie and Jarvis found that although there has been increased awareness of environmental risks, this coincides with uncertainty and a sense of powerlessness. Significantly large proportions of survey respondents were unable to 'agree' or 'disagree' with many of the questions posed: this was seen as reflecting not only a lack of 'information' but a position resulting from uncertainty in the face of disagreements among experts. It may also be linked with the finding that there were high levels of mistrust of business and government in relation to environmental issues, and the fact that almost half of the sample expressed 'anti-science' sentiments.

Ambivalent findings have emerged from another very extensive and detailed sample survey carried out by UEA and MORI (Poortinga and Pidgeon, 2003). They found that although most respondents had 'positive' views of science, almost 40% said that we put too much trust in science, and almost 69% relied that there is so much conflicting information that it is difficult to know what to believe. Poortinga and Pidgeon asked people about five 'risk issues' –

climate change; radiation from mobile phones; radioactive waste; genetically modified food; and genetic testing. Respondents were interviewed and asked whether and how

they were interested in any of these - about 20% of the sample were *not* interested in any. The least interest was in GM food (cf Shaw) and radiation from mobile phones; the most interest was in genetic testing and radioactive waste. People were specifically asked how strongly they felt about risks associated with these: the findings show that between one-quarter and one third were in the 'mid-point' category, that is 'Neither Good Nor Bad'. Many people were indifferent or unable or unwilling to express an evaluative opinion. Perhaps even more intriguing, in this study - one of the largest and most detailed investigations of public risk perception undertaken in Britain - among the respondents the five risk cases were seen as less important than other personal and social issues.

Thus the conventional view - that we can expect laypeople to be made aware of scientific, medical or environmental risks, or that they can evaluate them and prioritise them relatively, or that they can be better educated or informed about them through improved communication and consultation - begs a vast range of questions about the so-called public understanding of science, and about the complex social relations surrounding knowledge, risk and trust. It also returns us to the conceptual and methodological problems of how to investigate public perceptions of the adoption and impact of a Hydrogen-based technology and economy.

Knowing the Unknowns in the Hydrogen economy?

Following Beck (1992; 1996; 2000) and Giddens (1991; 1995), late modern society is a risk society. Science and technology have transformed the natural and social worlds but have also resulted in new risks and hazards. For Beck such hazards have displaced

previous material inequalities as new sources of conflict and social division. Chemical, ecological, genetic and nuclear risks cannot be fixed in space or time; they are not easily explainable in conventional terms of causality or liability; and they cannot easily be insured or compensated (if at all). Uncertainties are routinely and systematically manufactured in risk society, yet hazards are frequently invisible or untraceable. Barbara Adam (1998) has stressed that many contemporary scientific, technological and environmental hazards are indeterminate and even unrecognised (as yet) and that this is problematic to reconcile with science and risk management systems based on axioms of certainty, prediction and control. As Beck (2000, 217) emphasises, risks both originate from and consist of 'un-awareness' or non-knowledge, and that in itself poses fundamental uncertainty:

> "If we cannot know the effects of industrial research,
> action or production - if neither the optimism of the
> protagonists nor the pessimism of their critics is
> based on certain knowledge, then is there a green light
> or a red light for techno-industrial development and mass
> utilisation?".

This is more than a rhetorical question, because government and industry - and the public understanding of science 'movement' - have all accommodated to the demands for greater public awareness of and involvement in scientific and technological risk assessment. The practical problems are - how can these issues be empirically examined, and how can valid and reliable data be obtained, and how is such evidence about public perceptions (beliefs, attitudes, values) be interpreted?

One of the most important and recurrent findings from studies of public perceptions of science and environmental risk - and this is directly relevant to the investigation of a possible Hydrogen economy - is the nature and scale of 'Don't Knows'. As noted previously this was, in the PUS model, regarded as a sign of public ignorance or 'knowledge deficit'. However, as Mike Michael has argued, the apparent absence of knowledge must not be mistaken for ignorance or disinterest (Irwin and Michael, 2003). Michael's study of people's beliefs about radon and ionising radiation (1996) identified a discursive jigsaw comprising elements of scientific knowledge, lay knowledge and personal 'knowledgeability' reflecting particular cultural experience. In this study, Michael found three 'discourses of ignorance':

- (i) "mental constitution" referred to those people who said that they were incapable of grasping the science

- (ii) "division of labour" referred to those people whose 'ignorance'- they said - was a consequence of their role or occupation, so that they simply did not see the knowledge as necessary or relevant to them

- (iii) "deliberate choice" reflected the views of those who regarded the issues as irrelevant or peripheral to their everyday lives.

Turner and Michael (1996) explored these discourses further and concluded that survey respondents or interviewees who proffer "Don't Know" answers to questions about science and risk are probably revealing the deep-rooted feelings of ambivalence and uncertainty characteristic of late modern or 'risk society'. Respondents expressing unwillingness to answer structured choice questions may also, Turner and Michael argue, be displaying a positive political preference - as well as a refusal to comply with the questionnaire method of restricted options - because these fail to capture the

interviewees' biographical narrative and social context. This is also partly reflected in Tulloch and Lupton's (2003) studies which showed how different methods on asking people about 'risk' elicited very different discourses of risk.

Without going into the methodological dispute about the most valid and reliable ways of measuring beliefs and attitudes, and the efficiency of precoded questionnaires versus unstructured interviewing versus focus groups etc - it is nevertheless important to be cautious about interpreting the apparent absence of a view or opinion. It must be noted that there is a longstanding problem in social science survey research with the assumption first that people DO have beliefs and knowledge about specific issues, when these may not already exist until posed by an interviewer - the so-called 'expectation of opinionatedness'. Phillipe Converse (1964) warned of the measurement error entailed in assuming that respondents actually do have certain opinions, and assuming that these are coherent and stable (see Converse J and Presser, 1986; Schuman and Prosser, 1981) - people may have 'non-attitudes'. The crucial point here is that in addition to any technical difficulties in research instruments, there are significant epistemological problems in understanding the meaning of 'Don't Know' replies to questions particularly to those about environmental risk.

Conclusions

If we compare some of the arguments about the significance of lay beliefs in health and illness with those about the public understanding of science more broadly, some common themes emerge. The first is that in each case, expert- and lay- knowledges are

conventionally seen as distinctive and potentially divergent. Just as so-called 'popular epidemiology' is seen as a means of incorporating the experiential meanings of health/illness in accounting for disease and treatment, so too is 'citizen science' regarded as a means of compensating for the 'deficit' assumptions inherent in the public understanding of science model. But as Irwin and Michael (2003, 87) acknowledge, rather than juxtaposing the public and experts, the nature of science-public interaction is better seen as 'heterogeneous and relational'. The second observation is that an absolute dichotomy between constructivist and realist approaches in each sphere may be exaggerated and misleading. As Prior (2003, 45) noted, patients can have extensive knowledge of their own lives and conditions, but they are not experts in medical diagnosis or treatment. Similarly, as Beck (2000, 212-213) commented more generally, to understand 'the complex and ambivalent nature of risk' it is necessary to use both realism and constructivism: risk and the public definition of risk 'are one and the same', and 'the notions of constructivism and realism, although seemingly incompatible, can complement each other'. Perception, Beck notes, 'is always and necessarily contextual and locally constituted' (op cit, 219), but also necessarily partial. Third, there are special and particular problems in dealing with issues in which laypeople have no direct experience and/or limited knowledge, and/or the science and technology themselves are new. Again Beck stressed the significance of growing unawareness and non-knowledge as a source of increased risk, especially where the hazards are 'latent and immanent, that is, invisible and untrackable to everyday perceptions' (ibid; my emphasis).

This then finally brings us to the task of investigating public awareness of the implications of an emergent Hydrogen energy economy, when knowledge among the

general population about Hydrogen energy and its possible applications is likely to be minimal or even non-existent. This is not the place to debate the relative merits of eliciting public opinion through quantitative versus qualitative methods, or the use of focus groups or Delphi techniques or citizens' juries or other deliberative mechanisms. Rather, the point at this stage is to emphasise that any study of public awareness of Hydrogen energy and the Hydrogen economy will depend on specifying its possible and probable uses, indicating alternative assessments of their potential benefits and risks, and anticipating that respondents' understandings of it will be mediated by a complex of factors including their general perceptions of the credibility of the science that underlies it, their trust in industries and regulatory bodies responsible for its workings, and its relevance to their immediate everyday concerns.

That is the next stage in our research.

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