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ORIGINAL ARTICLE

Leaping "Out of the Doubt"—Nutrition Advice: Values at Stake in Communicating Scientific Uncertainty to the Public

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Abstract This article deals with scientific advice to the public where the relevant science is subject to public attention and uncertainty of knowledge. It focuses on a tension in the management and presentation of scientific uncertainty between the uncertain nature of science and the expectation that scientific advisers will provide clear public guidance. In the first part of the paper the tension is illustrated by the presentation of results from a recent interview study with nutrition scientists in Denmark. According to the study, nutrition scientists feel their roles as ''public advisers'' and ''scientists'' differ in that the former involves an expectation that they will provide unambiguous advice of the kind that might relegate scientific uncertainty to the background. In the second, more general, part of the paper we provide a normative analysis of different strategies of dealing with the tension. The analysis is structured around the extremes of either total concealment or full openness regarding scientific uncertainty. The result of analysis is that scientific advisers should not simply ''feed'' scientific conclusions to the public. They should rather attempt to promote the ability and willingness of the public to assess and scrutinize scientific knowledge by displaying uncertainties in the scientific basis of advice. On the other hand, scientific advisers must accommodate the public's need for guidance. Such guidance should be restricted by careful consideration of what it is relevant for the public to know in order to evaluate scientific advice in practical terms.

Keywords Appearance of certainty · Autonomy · Public · Scientific advice · Scientific consensus · Scientific uncertainty

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Introduction

The role of scientific adviser to the general public can be challenging, because of possible tensions between the requirements of science and the requirements of scientific advice. One area of tension concerns the management and presentation of scientific uncertainty. While uncertainty is at the heart of science, scientific advice may seem to call for certainty, and for simple recommendations and assurances.

At a general level it has been claimed that scientific advisers to the public are under pressure to present an appearance of certainty. They are said to be faced with societal expectations that often require them to adopt and defend firm conclusions even when uncertainty exists [13, 19, 20]. Scientific advice to the general public on the basis of uncertain science may thus seem to involve a complex choice in which the communication of scientific uncertainty has to be balanced against the expectation that definite answers will be provided—a balance that might compromise the scientific basis of the advice. If the advice is very simple or unambiguous it may not truly reflect the underlying scientific complexities. If, on the other hand, it is too complex, it may fail, in practice, to offer real public guidance.

In any case scientific advice often has to be made. Scientists in fields of applied science such as human nutrition, the environment, climate, and health more generally that involve issues of urgency and public attention will often find that they have to give public advice on somewhat shaky grounds. The general aim of this article is to analyse the values and concerns at stake when such scientists advice the public in the face of scientific uncertainty.

In the section entitled ''The Interview Study'' we present results of an interview study on the values and reflections of scientific advisers working in the field of nutrition in Denmark. In the ''Strategies'' section we use these findings as a starting point for a normative analysis of the values at stake in communicating scientific uncertainty to the public. In the analysis we consider the extremes of either total concealment or full openness regarding scientific uncertainty, and the way in which these extremes are intertwined with questions about the moral role of the scientific adviser to the public—i.e. about whether that role is ultimately to tell people what to do, or rather to enable people to make up their own minds. In considering the extremes the aim is to identify concerns that are relevant in order to find a reasonable balance.

While the point of the normative analysis is to clarify the values involved it involves a certain degree of abstraction at the expense of contextual detail. The aim is to clarify—at a more general level—the central values at stake in communicating scientific uncertainty to the public and to identify concerns that point towards a reasonable way of dealing with scientific uncertainty in scientific advice. We hypothesize that the normative analysis has wider scope, i.e. that its relevance goes beyond the field of nutrition to related fields of applied science which also provide public advice under conditions of public attention, uncertainty of knowledge and a certain degree of urgency. To begin with, however, we wish to make a few additional remarks about the approach taken in this article. Before the interview study we shall also briefly explain our use of the concepts of ''scientific uncertainty'' and ''public advice''.

With its focus on values and concerns of scientists the article differs substantially from standard approaches within Science & Technology Studies that typically analyse the relation between scientific experts and the public on the basis of political or institutional (societal) factors with little detail from the actual experience of scientific experts [25, 26]. The theoretical frame of reference for the present article is also somewhat different in that it mainly lies within Moral Philosophy and Philosophy of Science that has a long tradition for the analysis and discussion of values (see for instance [12, 21]). It is thus an assumption of the article that a clearer picture of the values and concerns of scientific advisers regarding the communication of scientific uncertainty supplies additional, important information to the understanding of the actions and priorities of scientific experts. Moreover, the article is also informed by the idea that to address the values of scientists and to engage in a reflection and clarification of these values is a legitimate way to bring about change (if necessary) or alternatively to retain status quo on a more considered basis.

Scientific Uncertainty

Uncertainty can be ascribed either to the results of science or to the scientist. Often it will be ascribed to both. Thus results can rest on a more or less secure foundation of observation and theory; and the scientist can be more or less certain about the views, or the results, he or she is presenting. To be uncertain, as we understand it here, is to have incomplete knowledge *and* to be aware that one has incomplete knowledge. Contrast ignorance, where a person also has incomplete knowledge *but* is not aware that this is the case. While incomplete knowledge provides a necessary condition of uncertainty, the two conditions are not the same [16].

Scientists may be uncertain because they have problems with scientific evidence: this could be due either to problems obtaining the necessary data at all, or to difficulties obtaining data of sufficient quality—something that, again, might be due to measurement errors, problems of generalization from one set of data to another, lack of money, lack of time, and so on. The ability to control this kind of ''empirical uncertainty'' is an integral part of the scientific process. Thus, normally scientists will be fully aware of this kind of evidential weakness (if it exists) both in their own results and in the results of other scientists on whose work they are basing their views.

Alternatively, scientists may be uncertain about the adequacy of a theoretical framework. For example, they may be in doubt about whether to try to understand problems relating to human nutrition merely in physiological terms or whether also to regard these problems as psycho-social in nature—and, if the latter, they may wonder how to combine the two perspectives. They may be in doubt, when they find regularities, about whether these regularities reflect causal relationships or whether instead underlying factors, so far undetected, determine the regularities so far uncovered. Hence, they may be in doubt about whether they have really begun to understand the problems they are studying, or whether they are in fact scratching the surface of highly complex issues. ''Theoretical uncertainty'' of this sort may be less widely recognized than empirical uncertainty. Typically, it will only surface at a time of scientific crisis, when a certain scientific paradigm is under pressure,

although at other times it might be felt by marginalized scientists who work on the borders of different scientific approaches [4].

Scientific Advice to the Public

It is an important role of scientists working in an area of applied science, such as human nutrition, to provide expert advice. The advice may involve making recommendations on issues of nutrition, and more particularly health and nutrition: for example, on what kinds of diet help to reduce or maintain weight, on causal connections between various kinds of food and disease, and on the links between consumption and genetic dispositions. Naturally, scientific advice will take different forms, depending on who is being advised. There can be direct advice to individuals in the form of individual counselling. At the other end of the scale, there can be scientific advice to the industry or policy advice (as, for instance, with various kinds of risk assessment where the advice is mainly directed at central administrators), which is not necessarily known to the general public. Finally there can be advice directed at the wider public, or the public as a whole. This last kind of advice is our topic here.

Advice to the general public on issues of nutrition can be transmitted in various ways. It may consist in a press conference where nutritional experts present the recommendations of a recent expert report on a specific issue. Such reports are typically made by a group of experts that has been brought together in order to synthesise and conclude on the basis of the available knowledge. It may also consist in individual experts (or research groups) who get attention in the media by presenting their recent projects or novel scientific results or comment on the results of other researchers. Most often however it involves journalists who present the views of scientists based on interviews with the scientists or on a reading of their papers or reports. This frequently seems to be brought about on the initiative of journalists who contact scientists for comments and advice in relation to cases that have come into prominence at the public agenda on a national or international level. In these latter cases the public communication of scientists is not always explicitly framed as a recommendation to do, or refrain from doing, something. In practice, such communication may nevertheless be conceived as a recommendation by the public, even when it was not intended to be. This is because human nutrition is an area that is close to everyday life (that is, to lifestyle, food choices, eating habits, personal appearance, and so on) and thus a subject that is bound to attract eager public attention. Indeed there is often a remarkably short distance from research to scientific advice: public statements, or claims by scientific experts, are often turned into headlines in the media and swiftly transformed into more or less explicit recommendations. In the following discussion we use the notion of scientific advice broadly and flexibly, so as to include a wide variety of communicative activities involving the general public.

The Interview Study

The interview study we shall present concerns scientific advice to the general public on human nutrition. Nutrition is a field in which the scientific knowledge base is

controversial and thus falls well short of an ideal of complete knowledge. The uncertainties of nutrition scientists are not all empirical. That is, they are not merely the result of inadequate evidence that could in principle be improved by the devotion of more time, more research and more money to work on nutrition. They are also due to the fact that the field of nutrition is in general difficult to investigate and describe using scientific methods. Each kind of scientific method has its own difficulties and limitations here. Epidemiological studies, for instance, have to be sensitive to the bias of selective reporting and the notorious problem of distinguishing between causal mechanisms and random regularities. In clinical, intervention studies, on the other hand, it is often crucial to ask to what extent any results can be generalized beyond the controlled experimental set-up [9].

The interview study was conducted in Denmark in 2004–2005. The aim of the study was to explore the values and reflections of nutrition scientists in relation to their role as public advisers. The interviews took as their point of departure a specific case: the Danish variant of what was, in fact, during the 1990s, an international controversy over the relationship between sugar and obesity. At this time scientific opinion was divided over whether sugar is fattening, and over the extent to which sugar can be converted into fat by a process known as De Novo Lipogenesis. The controversy also involved a dispute over the interpretation of the scientific evidence and a less clearly articulated conflict over the point and limits of public advice on scientific matters [4]. This case was chosen in order to provide a common focus for the interviews and to offer a specific, realistic point of reference in discussions broadening out to incorporate wider perspectives on public nutrition.

The study involved 16 qualitative, in-depth interviews. Eight of these involved prominent nutrition scientists (full professors or associate professors, seven male and one female), six of whom had trained originally as medical doctors. One of the remaining two scientists interviewed was trained as a biologist; the other as a biochemist. The scientists were all middle-aged and affiliated to a university. They were selected strategically on the basis of some degree of public involvement in the case and experience with the role of public expert on nutrition issues (through their membership in the independent Danish Nutrition Council, or appearances in the media, or both) [3]. The other eight interviewees were well-informed professionals working in the field of nutrition policy. They included two dieticians, one politician, and five central administrators in government departments dealing with health and nutrition (four were male, four were female). They were recruited as ''key informants'' [7]. While the interviewed scientists were at the centre of the object of study, the key informants were expected to contribute background information relating to their professional fields.

The interviews were semi-structured. They used an open-ended interview guide which invited respondents to develop the themes introduced in directions of their own choosing [15]. The interviews with scientists focused initially on details of their role as providers of scientific expertise to the public, their involvement in the controversy over sugar, and its general importance and implications. On this basis, a more general conversation was pursued about the role of the scientific expert vis-à-vis the public, including issues relating to scientific consensus, controversy and the communication of scientific uncertainty. Key informants were interviewed about

their views on the same issues; they were encouraged to look at matters from their positions in the field of nutrition. The interviews lasted between 1 h 30 min and 2 h 30 min. They were recorded with a digital voice recorder and transcribed verbatim. The material thus prepared amounted in total to approximately 1,000 pages of text.

The approach taken to data coding and subsequent data analysis was based on Template Analysis [3, 14], and on Coffey and Atkinson [1]. On the basis of the focus of the study, together with a thorough, sentence-wise identification of themes and sub-themes in four full transcripts that had been selected for their special quality after careful reading of all transcripts, an initial template (i.e. code-system) was developed. This identified the central issues in the interviews. The initial template was descriptive. It included codes such as ''experience with the case of sugar'', ''views on the case'', ''contact with the public'', ''views on scientific disagreement'', ''views on scientific uncertainty'' and ''experience with the food industry''. The template was developed in order to get an overview of the material and to break up the analysis into smaller units. In the coding process ATLAS.ti (Visual Qualitative Data Analysis, Version 5.0.66) was used. Coded segments were summarized, and analysed code-wise, to arrive at a thematic analysis of four general themes. The analysis presented below focuses on the communication of scientific uncertainty. Additional themes relating to the public impact and credibility of nutrition experts, nutrition experts' independence from commercial interests, and normative issues in nutrition experts' evaluation of the scientific evidence have been discussed elsewhere [5, 6]. The quotations we present below all derive from the interviews with scientists. They have been selected because they represent typical or common responses, including responses that embody concise formulations of specific themes. To ensure anonymity, no characteristics of the interviewees are given.

Results

In the study the scientists generally felt that their roles as ''public advisers'' and ''scientists'' were different in that the former involved an expectation to provide clear and unambiguous advice of the kind that might relegate scientific uncertainty to the background. This expectation gave rise to a certain amount of frustration, because it seemed to conflict with central ideas about what it is to be a scientist. Within their disciplines scientists are required to critically assess both their own work and the work of others. It is generally accepted that results are often provisional and may well be subsequently revised. Scientific advice-giving, on the other hand, were seen to involve a requirement to leave the scientific doubt behind. One of the scientists described scientific advice-giving as a matter of taking a step from scientific doubt to an acceptance that a certain course of action is right:

> Scientist: Even if we have this doubt that drives research forward [...] then there is a another element, and that is if the researcher steps out of his role as a scientist in order to give advice to the public [...] then you have to leap – almost as described by Kierkegaard – qualitatively you have to take a leap out

> of the doubt you have as a researcher into the decision... the choice to believe that this is the truth after all, and that this belief has such strength that you choose to act on it. This leap... some people are willing to make it easily while others are more worried. And some refuse to make it at all. They won't risk – again in the terminology of Kierkegaard – the seventy thousand fathoms of water.

The step from the state of uncertainty (science) to acceptance that a certain way to handle a problem is the right one may not be an easy one for scientists to take. It is a step in which the scientist must try to handle the doubt and uncertainties inherent in scientific material. In the interview study the scientists described the sense in which these conditions of science were swept aside in their role as public advisers – in the words of the scientist quoted above they had to: ''leap out of the doubt''. Another scientist described the step as one in which he had to go against fundamental ideas about what science is or is supposed to be.

> Scientist: Science is...science has to be driven by doubt regarding the correctness of your results. If you lose this doubt, then you have lost the fundamental idea about science. So I mean you should always carry the doubt that what you have found is right. Because you know very well that the next trial can provide different results. At the same time you face a public who want to know...who has a right to conclusions. We often say that we need more money because we have to do more research. But...no public authorities will continue to accept that.

The requirement of clear guidance, as experienced by the scientific advisers, was thus seen to be at odds with their self-conception as researchers. It was also a requirement that some found difficult to meet:

> Scientist: Scientific advice, you know... they ask you to read a crystal ball, but it is really difficult to do this in a balanced way.

In their attempts to live up to this need for clear guidance, some of the interviewees even seemed to feel an ''expectation of certainty'', i.e. a requirement to appear more certain and unambiguous than was warranted by the relevant scientific findings.

> Scientist: Many people have such a simplistic conception that something is right and something is wrong. But that is not the way it is in the results we achieve. In our results something indicates one direction while other things indicate other directions. But very often we are required to report clearly what is right and what is wrong. Often that is not possible. And... well... at the same time you are also...at the same time you perhaps also signal that you are more certain than is actually the case, because sometimes you have to... Consider the analogy between a doctor and his patient. If the question is whether the patient should have an operation, sometimes you end up saying that an operation is the right thing to do – even though you know in your heart that you are uncertain about it.

In addition to this expectation that clear and unambiguous advice would be provided—an expectation described as coming from the outside—the study also revealed a more internal push in the direction of an appearance of ''certainty''. This was an expectation upheld by nutrition scientists to approach the public by means of a scientific consensus.

> Scientist: We cannot afford to communicate in disagreement, when it is about... when the issue is what the experts know. I mean they are supposed to have the most knowledge about a given field. What kind of advice are they able to give? They *have* to provide a consensus. Minority views are no good... they make the advice useless.

The expectation regarding consensus was seen to be connected with the fact that scientists work not only as individuals but also in groups of researchers in particular fields—something which places a restraint on the individual scientist to confer with colleagues, and if necessary adjust his or her views accordingly, before going to the public. At a general level scientists as public advisers have been said to pay tribute to a ''professional ideal'' of consensus which prescribes that scientists should never disagree about the facts in public [19, 24]. Rather, they should refrain from speaking out until they have reached a solid consensus among themselves. Collective advice thus introduces a further complicating factor. While the individual adviser has to deal with scientific uncertainty collective advice-giving may also involve the management of divergent views among experts.

Strategies

The interview study suggests that it is as a real challenge for scientific advisers to manage the tension between their scientific uncertainty and what they perceive as a public expectation that they will provide clear advice. In what follows we present a further normative analysis of the general strategies that can be employed to resolve the tension identified in the study. The analysis is structured around extremes at each end of a spectrum: to either convey all scientific uncertainty to the public or to wholly conceal it and give advice which is not only clear but also appears to be certain. As we will argue, these extremes are intertwined with normative issues that bear on the moral role of the scientific adviser to the public.

To Conceal Scientific Uncertainty

According to a traditional paternalistic strategy, scientific advisers should provide apparently certain, indisputable knowledge. Doubt and uncertainty should be concealed from the public. This ''top-down'' strategy is based on the supposition that it is the primary role of the scientific adviser to feed scientific conclusions to the public, and that the adviser should act as an authority that settles matters once and for all.

Following widespread attention to patient autonomy in medical settings—and the focus in medical ethics since the 1970s on the concept of autonomy—open

employment of this strategy has been in decline for many years. However, when it comes to practice, and especially in situations that are less regulated than that involving the relationship between doctor and patient such as public advice-giving, the situation can be quite different. The nutrition scientists in our interview study clearly felt an expectation that they would be able to give very clear advice—which, as we have seen together with the commitment to science, created the dilemma of being true to science or being true to the expectations of scientific advice.

Given this dilemma, we can sensibly ask whether scientists should attempt to meet such expectations by means of authoritative advice. In answering this question it is a good idea to consider what is truly valuable about scientific advice. In reality, this cannot be the provision of certain, indisputable knowledge, since this is often difficult or impossible even for experts to give. What experts are typically able to provide are qualified judgements regarding their domains of expertise and critical commentary on these judgements [2, 22, 23]. Given this, experts should be reluctant to accept the role of providers of certainty.

It seems more sensible instead to locate the practice of public advice in a general normative framework that aims to respect and promote the autonomy of citizens. Within such a framework the purpose of scientific advice is to make scientifically based recommendations available to the public, so that individuals can take account of the scientific evidence when they make up their minds about what to do. Rather than seeking to appear certain, scientific advisers thus attempt to nurture the ability of the public to assess and scrutinize knowledge by displaying the foundations and uncertainties on which their advice is based.

An interesting side-issue in this connection is whether the public's expectation of certainty is actually real: do people genuinely expect scientific advisers to be certain? Members of the public might indeed be fully aware that science, like everyday life, is fraught with various kinds of uncertainty—especially in fields such as the area of nutrition, which are generally known to be controversial and attract considerable public attention.

According to Irwin and Wynne [10, p. 215] the ''public expectation of certainty'' is really a construction created by the scientific community in order to maintain a contrast between scientists (who know about the uncertainty) and the public (who do not). In reality, these authors claim, the public understanding of science is much more nuanced. In the same vein, it has been claimed that the pressure on scientific advisers to appear certain ultimately persists because a number of interests are thereby served [19, 20]. Thus an air of certainty may be useful to experts because it bolsters their own standing and confirms the status of their area of expertise—something which may be very important for research funding and public impact. The appearance of certainty can also be understood as part of a strategy employed in an attempt to rule out criticism and protest. It may also be useful to those officials, decision makers and parts of the industry that use science strategically to (among other things) bypass responsibility and to avoid debate, or to invoke science to legitimize or back-up their claims, or undermine the claims of their opponents [17]. Again, the association of scientific advice and certainty may be reinforced by

journalistic practices that tend to simplify, downplay or even omit qualifications and uncertainty when reporting the claims of scientists.

These suggestions imply that the expectation of certainty is shaped by an unfortunate mixture of (scientific) self-interest, strategic thinking, and the logic of the media. Although this explanation is likely to contain some truth, its detailed veracity or otherwise cannot be settled in this article. The picture it paints of scientific advisers, however, does seem one-sided. Like most other people, scientists are likely to have concerns other than pure self-interest and strategic thinking. In the interview study, for instance, the scientists seemed to be genuinely concerned about public interest, although it could not be directly inferred from the study what, precisely, such concern implied.

To Convey Scientific Uncertainty

We shall now discuss the second strategic extreme we mentioned, i.e. that of conveying all the scientific doubt and uncertainty in offering advice. Such a strategy might actually seem sensible, especially if the public does not expect certainty from the scientists and in general holds a nuanced view of the nature of science. In effect, to employ this strategy would be to abandon the idea that the scientific expert should somehow act as a filter or mediator between science and the public: when communicating any genuine scientific uncertainties, the adviser would not have to make a distinction between the public and his or her scientific colleagues. In this sense, the strategy will potentially diminish the contrast between the roles of scientist and public adviser reported in the interview study.

Although this might seem attractive for scientists, it is not ultimately a strategy that will serve the public. Any attempt to give a complete account of scientific uncertainties will involve efforts to describe all the uncertainty in the evidential basis and the way in which this relates to the scientific advice. This, in turn, will involve a consideration of all the possible sources of uncertainty at the evidential level, such as potential measurement errors, problems of generalization, and the like [16]. This may turn out to be a very arduous task. Explaining theoretical uncertainties may be even more difficult for the scientist. Even when they are communicating among one another scientists are, of course, selective about which aspects of uncertainty they bring forward. If a wider public is involved, any attempt to give an exhaustive account of the uncertainties they face would no doubt result in epistemic chaos.

Ordinary citizens often do not have the scientist's informed opportunity to assess scientific claims and to weigh the importance of the various kinds of scientific uncertainty. This general epistemic contrast has been analysed by social epistemologists. Following Goldman [8], we should observe that it is difficult for the public to become justified in believing the views of experts on the basis of scientific arguments per se. This is because the public usually lacks (i.e. is not able to assess the truth-values of) all or some of the premises from which scientific experts reason to their conclusions. Members of the public are also in an inferior position when it comes to assessing the relations of support between the evidence being presented and any conclusions being drawn, and they are ignorant of many or

most of the defeaters that might bear on the experts' arguments. Similar epistemic difficulties occur when rival experts disagree in public. In this case it will often be impossible for the public to assess whether they are justified in believing one expert rather than the other. Instead of having the opportunity to assess the truth of the competing claims, the general public has recourse only to such ''indicators'' as the sources of the claims (who are rival experts and who do they work for), their performance in the media, personal charisma, and the like.

This raises complex issues about justification, but in this context the relevant point is that scientists, by comparison with the general public, are much better able to assess scientific knowledge—to provide qualified judgements within their domains of expertise. It is precisely for this reason that their advice is valuable, i.e. that there is good sense in our consulting expert advisers.

It is thus crucial to bear in mind that scientific experts are indeed *experts*. They have knowledge of matters that the public does not. Scientific experts are usually cognitive authorities in their own fields: they are much better able to make informed judgements within their domains of expertise than others [2, 22, 23].

Of course, it is important here to demarcate the area of authority delegated to scientific experts. Expertise in the sense specified neither translates nor generalizes: if someone is a scientific expert in one domain it does not follow that he or she is an expert in others (of a scientific, political, cultural or other kind). Thus to accept scientific advice as a key resource in the handling of public issues is not automatically to treat science as an authority in defining what the issues are [10, 11]. Neither can expertise as cognitive authority replace an engagement with the public to find out about their concerns, preferences, and interests.

To summarize the points made so far, scientific advisers should not aim to present the public with an exhaustive account of scientific uncertainty. They should accommodate the fact that members of the general public are unlikely to be able to navigate their way through the issues if they are provided with comprehensive details of scientific uncertainties, and that they therefore need to provide some sort of ''edited'' guidance.

The notion that the communication of uncertainties should be judicious and selective is not unique to public advice: it often applies when scientists communicate with each other. Today scientists typically communicate in scientific journals (where they are strictly restricted in space) and at scientific conferences (where they are strictly restricted in time). These limits in space and time necessitate careful selection not only of scientific results but also of the accompanying uncertainty. Such selection is typically driven by scientific interest: scientists choose to present what they consider to be most interesting from a scientific point of view, e.g. in terms of the advancement of scientific knowledge.

When scientists communicate with the public, however, it seems that the communication of uncertainty should be restricted in another way. There is no reason to expect that scientific interests in general overlap with public interests. When it comes to public advice, scientists should only communicate elements of their uncertainty that are relevant to the public. It is, of course, tricky to define public relevance and ''the public interest'' (diverse as these often are). One suggestion would be to understand the public interest (where the issues being

discussed here are concerned) in terms of what is minimally required for adequate public evaluation of scientific advice. Thus it may not be necessary for the public to know about various kinds of measurement error or statistical complexity when these are not likely to affect any final result or advice. Of more immediate relevance, on the other hand, would be an indication of the strength of the recommendation given—e.g. whether it is based on solid science (whether it involves risky generalizations), whether it is backed up by many studies, and whether it is controversial among experts. The public may also wish to know how a given scientific result relates to the ''bigger picture''. They may appreciate an idea of the role and place of the scientific conclusions in a wider scientific framework.

Balancing

We have now considered two extreme strategies in the communication of scientific uncertainty: either total concealment or an attempt to convey uncertainties fully. We have argued that scientific advisers should attempt to find a balance in which they encourage the citizen's exercise of autonomy while at the same providing epistemic guidance. We have also argued that such guidance should be restricted by careful consideration of the kind of information the public needs in order to evaluate advice in practical (not scientific) terms.

The required balance here may be sought in various ways. One way would be to give the *best judgement* of the scientific adviser. A best judgement, for present purposes, is a judgement that proceeds to an explicit recommendation, i.e. an expressed prescription for action framed in a clear and comprehensible way. The judgement must be clearly based on an assessment of the available knowledge within the field; it must be followed by communication of any uncertainties of which the public would need to be aware if they are to evaluate the advice in practical terms.

It may be difficult to specify a priori the exact kind of information that is necessary for an adequate public evaluation of advice. We made some suggestions at the end of the last section, but obviously specific details will depend on the subject matter, the kinds of uncertainty involved, and the characteristics of the targeted advisees, i.e. the subgroup of the general public that the advice is directed towards.

For illustration, consider the controversy over the fattening potential of sugar in the 1990s. During this debate nutrition scientists energetically discussed the extent to which sugar could be converted into fat by the process known as De Novo Lipogenesis. In spite of limited public relevance the scientific discussion in Denmark partly took place in the media, eagerly assisted by the sugar industry, which had been quick to exploit the controversy for their own purposes. From the early 1990s the industry launched a series of campaigns to ''educate'' the Danish public under slogans such as ''Some people still think that sugar is fattening'' and ''Sugar is not converted into fat but becomes energy for the muscles and the brain''. The result was a great deal of public confusion over the role of sugar. However, the scale of the confusion might have been less had the Nutrition Council issued a statement. Thus they could have given their best judgement

saying (i) that a high intake of sugar (above a certain daily amount) is fattening and should be avoided (the prescription); (ii) that this advice was based on the idea that an excessive intake of sugar as well as of other macro nutrients would result in the eater becoming overweight or obese; (iii) that nutrition scientists had different opinions over the consequences of a high intake of sugar and the effect of sugar on the appetite; but (iv) that since there was a shortage of studies of the role of sugar, there was no basis for acquitting sugar as a cause of obesity. In fact, however, it was not until 2003 that scientific advice along these lines was given to the Danish public, when the Danish Nutrition Council issued a report on the health implications of sugar.

A best judgement is therefore an assessment of the strengths and weaknesses of (purported) findings, and an attempt to balance those findings in an explicit recommendation. The latter is designed to provide an explicit element of guidance: it is indeed relevant to know *how* the expert, given his or her epistemic access to the field, assesses matters and concludes from the facts. On the other hand, people should not be reduced to passive consumers of unambiguous advice. They will in any case have to exercise autonomy and judgement when they choose either to accept the recommendation given or to draw a different conclusion.

In practice, it may be that something like best judgements are already realized—although tacitly. If so, such judgements should not remain tacit. Discussion of the normative issues raised by the management and presentation of scientific uncertainty is not only of theoretical interest; it may also improve practice by making it more considered and more consistent.

Again, in practice, such balancing is likely to be more complex than paternalistic alternatives, and more demanding on the scientific adviser. It places an extra obligation on the scientific adviser: to consider what kinds of uncertainty it is necessary for the public to be informed about. Best judgements (or equivalents) may also seem to have less impact than ''certain judgements'', as the admittance of uncertainty may blur the message. On the other hand, best judgement is more true to the nature of science, and therefore less likely to promote a false idea of what science actually is. When reality is complex, there is no honest basis for simple solutions. Finally, best judgements may even reduce the tension between the role of scientist and the role of scientific adviser, because, in them, clarity of guidance does not come at the expense of openness regarding scientific uncertainty.

The Relationship of One Scientist to the Other

A further complicating factor, however, is the relationship of one scientist to other scientists. As we have touched upon several times, scientists are not just individual actors. They belong to groups, or collectives, of scientists within their particular fields. And although individuals in these groups typically share the same paradigm and thus agree about most of the fundamental issues, they also disagree in ways that sometimes affects their preferred advice. Eventually, scientific experts will disagree in their best judgements.

As noted earlier, when the public encounter rival experts that contradict each other in their best judgements, the value of advice-giving will be compromised—it will cease to be rational for the general public to take such advice into account when they make up their own minds about what do to [8]. In this way, the element of guidance will be lost. Indeed in the field of nutrition some such effect might already have occurred in that too much conflicting advice seems to have resulted in a certain degree of public scepticism about the value of nutrition advice [18].

To counter such effects while at the same time promoting transparency about different, potentially conflicting, assessments of the facts and the scientific uncertainty is no simple matter. It requires further theoretical reflection and clarification. In the following paragraphs we add some comments designed to help take the issues forward here.

In the interview study the scientists seemed eager to avoid expert disagreement in public; they stressed the importance of approaching the public by means of a scientific consensus. In our view it may be worthwhile trying to build on this idea of a scientific consensus. However, there is also reason to be cautious, since consensus is often difficult to generate.

Consensus as a regulative ideal implies that competing parties should make an effort to consider the views of their opponents. It can thus pave the way for the resolution of factual disagreements resulting from lack of knowledge or inappropriate assessment of the relevant facts. The honouring of the ideal of consensus can also ensure that differences of opinion become clearer (are more openly articulated) in the process of arguing for and against. In practice, however, a consensus can also encapsulate complex forms of disagreement—including disagreement resulting from differences in values and different attitudes to the management of scientific doubt and uncertainty. Scientific controversies do not always result in a simple way from lack of knowledge.

It is therefore necessary to distinguish between two different levels at which a consensus can be achieved. At the first level, public agreement—unanimity—about the facts is the overriding concern. To reach this goal it might be necessary to suppress minority views, or to downplay scientific uncertainty. At the second level, however, the consensus sought is not about the facts but about the range of legitimate judgements that can be held in relation to the facts. The goal here is to reach an agreement of a higher order—a meta-consensus, so to speak, or an agreement about where to disagree.

It is consensus at this second level that there may be reason to pursue. Adopting the terminology we used above, whole *groups* of scientific advisers could seek to provide a *common* best judgement. Instead of a bunch of individual best judgements over the role of sugar, for instance, a common best judgement would involve explicit advice to avoid sugar, a clarification of any uncertainties here (as proposed above) *and* an indication of any minority best judgements.

Of course the uniformity and feasibility of such a common best judgement will vary with the size and nature of the differences in views, and the particular circumstances at hand. If the subject is controversial and the stakes are high, it might be difficult to create legitimate space in which such a meta-consensus can be formed.

Conclusion

In this article we have examined the tension, in the role of scientific adviser to the public, between the uncertain nature of science and the public expectation of certain, unambiguous advice. We have approached this subject from two angles. First, we have illustrated the tension by presenting an analysis of a recent interview study of nutrition scientists in Denmark. Second, we have tried to analyse some crucial, general, normative considerations bearing on the tension. We have suggested, first, that scientific advice to the public should be given in a normative framework that encourages citizens to exercise autonomy; and second, that, at the same time, there is a need for clarity of guidance, i.e. explicit prescriptions for action.

The notion of a best judgement of the scientific adviser introduced here seeks to accommodate both of the above suggestions. On the one hand, it is an attempt to promote public autonomy by displaying the relevant assumptions and to be candid about uncertainty in the basis of the advice. On the other hand, it acknowledges the public's legitimate demand to receive clear guidance: the scientific adviser must provide explicit recommendations on the basis of science, and then navigate between the various sources of uncertainty in order to present the subset of findings and theories that the public needs to evaluate the advice in practical terms.

These suggestions may not simplify matters. The provision of best judgements is a complex affair—one that is demanding both on the scientists who give the advice and the members of public who receive it. We hope, however, that the identification of relevant normative issues, and the invitation to reflect on the moral role of the scientific adviser to the public, may help to help to stimulate thoughts on how best to proceed.

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