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Public understanding of science in Britain: the role of medicine in the popular representation of science

John Durant, Geoffrey Evans and Geoffrey Thomas

This paper is based on the results of a random sample survey of the adult population of Britain. The survey was designed to explore public interest in, attitudes towards and understanding of science. The paper operationalizes the notion of scientific understanding, and applies the understanding measure in the analysis of social representations of science. The results suggest: first, that a so-called ‘deficit model’ of public understanding of science is useful for certain well-defined analytical purposes; second, that there are significant differences between professional and popular representations of science, and third, that medical science may be paradigmatic for the popular representation of science in Britain.

1. Introduction

The phrase ‘public understanding of science’ is multiply ambiguous. Who are ‘the public’? What is ‘understanding’? What is ‘science’? The general public is composed of many more-or-less distinct ‘publics’; understanding may be taken to mean knowledge and/or discernment, each of which may be defined in various ways; and, notoriously, the term science admits of no universally agreed definition. Different kinds of research make different choices among the many possibilities available here. Our aim has been to provide a rather general portrait of public understanding of science; and our method has been the social survey. We have conducted a survey of the British public as part of an Economic and Social Research Council (ESRC) research programme on the public understanding of science. The survey was conducted in June and July 1988, in parallel with a similar National Science Foundation ‘Science Indicators’ survey in the United States. Technical details of our British survey are provided in Appendix 1.

One virtue of the social survey is that by its nature it imposes a discipline upon the definition of target audiences and topics of study. For example, our survey was conducted among a random probability sample of approximately 2000 British adults over the age of 18. For our purposes, therefore, this constitutes ‘the public’. Traditionally, survey research in our field has tended to focus upon attitudes rather than understanding, and upon technology rather than science. By contrast, we have explored the nature and extent of people’s knowledge about these subjects, as well as their attitudes towards them; and we have been concerned primarily with science (by which we mean—roughly—the natural and the medical sciences, but not the social sciences and the humanities), rather than with technology. Of course, there are important precedents.
for our inquiry. For example, Boy has attempted to estimate the extent to which the French public differentiates among the sciences;¹ and in a series of studies over many years, Miller has measured levels of both 'scientific attentiveness' and 'scientific literacy' among the American public.² We have benefited from these independent approaches; but we have also developed our own measures of the nature and extent of scientific understanding.

Many of the empirical results of our survey have been published elsewhere.³ In this paper, we use a specific measure of scientific understanding as an analytical tool in the study of social representations of science. A social representation is any more-or-less distinct combination of ideas, images, beliefs and values that may be employed by a social group for purposes of identification and communication. In the present context, a social representation of science may be regarded as a characteristic 're-presentation' of matters scientific in the public domain. Our primary aim here is to identify some striking features of a popular representation of science in Britain, as these may be discerned within our survey data. Our approach involves making comparisons between relative levels of scientific understanding and a number of candidate representational elements, including ideas about the aims, nature, scope and status of science.

2. Scientific understanding

2.1. In defence of a 'deficit model'

Before proceeding to describe our measures of scientific understanding, we wish to address briefly a number of recent criticisms of a so-called 'deficit' model of the public understanding of science. According to the deficit model, science is seen as a well-defined body of knowledge, and the public is judged according to how much of this knowledge it possesses. In his published summary of the findings of the ESRC research programme on public understanding of science, Ziman claims that, 'a simple "deficit" model, which tries to interpret the situation solely in terms of public ignorance or scientific illiteracy, does not provide an adequate analytical framework for many of the results of our research'.⁴ Again, in the first issue of this journal, no less than three authors question the legitimacy of an approach that uses science itself as the yardstick against which to measure the nature and extent of public understanding of science.⁵

The critics have raised three principal objections to the deficit model. First, they claim that this model misrepresents science itself by portraying it as an unproblematic body of knowledge. For example, in his work with Cumbrian sheep farmers whose livelihood was threatened by the Chernobyl accident, Wynne has shown that some of the scientific advice offered to the farmers was seriously flawed because models developed in one context were applied inappropriately in another. Had the scientific advisers been more open to the very different (but equally relevant) expertise of the farmers themselves, then perhaps they would have spotted the need to adjust their models to take account of local circumstances.⁶

Second, the critics claim that the deficit model overlooks the fact that a great deal of scientific knowledge is both remote from and largely irrelevant to everyday life. According to Lévy-Leblond, for example, scientists and non-scientists alike are extensively ignorant about subjects outside their immediate sphere of personal or professional responsibility. On this view, all of us live in what might be termed a culture
of ignorance, in which it is quite impossible for everyone to be well-informed about everything. In this situation, survival depends upon the possession of great skill in acquiring just as much knowledge as it actually needed and no more; and since for most people most scientific knowledge is not needed, it goes largely ignored.

Third and last, the critics claim that the deficit model is either explicitly or implicitly normative; that is, they suggest that the model embodies the specific value judgment that scientific understanding is inherently good. On this view, advocates of the deficit model are presumed to be of the opinion that the public ought to know about science, since those who are knowledgeable are somehow morally and socially superior to those who are not. The criticism here is, presumably, that it is mere professional or even theological prejudice that holds one particular type of knowledge to be inherently worthier than another. Thus, Fayard pleads that we should 'stop persecuting people who do not think like Galileo!'—rather as if science education were the latter-day equivalent of the Spanish Inquisition.

There is much to agree with in the perspectives offered by Wynne, Lévy-Leblond and Fayard. Certainly, a great deal of scientific knowledge is problematic, either in the sense that scientists themselves may be uncertain or unable to agree with one another, or in the sense that the applicability of scientific knowledge to particular social problems is unclear. Certainly, also, we live in a culture of ignorance in which no-one can be expert at everything. And finally, even the most ardent enthusiast of the wider dissemination of scientific understanding in society would surely agree that it is both inappropriate and unhelpful to stigmatize those who do not measure up to any particular standard of 'public understanding of science'.

Thus far, the critics are surely right; furthermore we believe we would agree with Ziman that, for these and other reasons, the deficit model is not suited to handling all aspects of the relationship between science and the public. In other words, we accept that there are particular issues in our field that require different treatment. Nevertheless, we find it hard to see that these qualifications provide good grounds for abandoning the deficit model altogether. Thus, while we have conceded that a great deal of science is problematic, it must also be acknowledged in return that a great deal is not. Vast areas of scientific knowledge are relatively unproblematic, in the sense that all competent experts agree about them. This means that there is a reasonably stable body of knowledge against which levels of public understanding of science may be measured.

Again, we have conceded that all of us are extensively ignorant about matters that lie outside our spheres of professional activity or personal interest. However, this does not mean that it is either unrealistic or unwise to aspire to a level of universal education in which everybody possesses at least some elementary knowledge of a whole series of subjects (art, history, politics, science, etc.) in which they will probably never become truly expert. We do not share Lévy-Leblond's apparent willingness to divorce the ideals of democracy and literacy. On the contrary, we believe that the healthy functioning of democracy depends crucially upon the existence of a literate public; and in modern industrial democracies, true literacy must embrace scientific literacy.

Finally, there remains the problem of stigmatization. Clearly, to measure levels of scientific understanding within a population is inevitably to assign higher scores to some individuals than to others. By analogy with the notoriously controversial issue of IQ testing, this may be seen as inherently normative. Surely, it may be said, by measuring scientific understanding we are automatically branding as inferior those
who score badly? Not at all. It is worth remembering that the French psychologist Alfred Binet developed the IQ test in order to identify those pupils who were most in need of educational assistance. Later, IQ scores were widely used to identify the specially gifted. To be sure, psychometry may be used to target resources in many different ways; but the example of Binet himself demonstrates that there is nothing necessarily prejudicial about the wish to find out how well individuals are doing in any particular area of educational or scientific attainment.10

Questions such as ‘How much science do people know?’, and (superficially similar, but fundamentally quite different) ‘How much do people know about science?’ are not the only ones that may be asked by those investigating the public understanding of science. However, the idea that these questions are somehow improper is not merely unfounded but—in the end—deeply patronizing to the public itself. It is worth inquiring about the extent of the public’s scientific understanding, not least because this enables us to find out whether and to what extent such understanding has consequences for the ways in which people deal with science in their everyday lives. If we wish to learn more about the complex networks of ideas, images, beliefs and attitudes that constitute the social representations of science in any particular culture, then one thing we shall surely need is some measurement of public understanding of science relative to the benchmark of science itself.

2.2. Measuring scientific understanding

Leaving aside the philosophical question of the nature of understanding itself, it seems important to distinguish between at least three different objects of scientific understanding: understanding of the intellectual products of science, i.e. scientific knowledge; understanding of the formal processes of scientific inquiry, i.e. scientific method(s); and understanding of the institutional structures of science, i.e. scientific culture.11 Formal science curricula generally concentrate upon the first, pay some attention to the second and more or less completely ignore the third of these objects of understanding. Indeed, one influential school of thought in the United States seeks to define the construct ‘scientific literacy’ exclusively in terms of the possession of a minimal level of scientific knowledge alone.12

This school of thought is, however, in the minority. More commonly, recognition is given of the need to take account of the multi-dimensional character of scientific understanding. Thus, for example, Miller has offered a three-part definition of ‘scientific literacy’. On this definition, to be scientifically literate is to possess a minimal acquaintance with: the processes of scientific inquiry; basic scientific constructs; and basic science policy issues. Miller uses social surveys to estimate levels of scientific literacy among the US public according to this definition. Questionnaire items on each area of understanding are developed; minimum acceptable scores on these items are defined; and respondents are required to ‘pass’ on each area. In this way, Miller has calculated levels of scientific literacy among the US public that have varied between 5% and 7% over more than a decade.13

Thus defined, scientific literacy is a threshold concept; that is, respondents are judged to be scientifically literate (or not), according to whether they come up to the minimum acceptable level of attainment. This approach has the twin strengths of simplicity and starkness—the conclusion that, say, only 5% of the American public is scientifically literate is easy for educationalists and policy-makers to grasp, and for
newspapers to report. However, it has the twin weaknesses: first, that it depends on the setting of an arbitrary minimum acceptable level of attainment; and second, that it is not well suited to the purposes of statistical analysis. Less prejudicial on the first count, and more useful on the second, would be a scalar rather than a threshold measure. Scalar measures (such as IQ) rank all respondents in terms of their relative levels of attainment. Good scalar measures use multiple items that can be shown to possess high levels of consistency with one another and that yield roughly normal distributions of aggregate scores.14

In this study, we have measured scientific understanding on two different dimensions: understanding of the factual and theoretical contents of science (henceforth, knowledge); and understanding of the intellectual and practical processes of scientific inquiry (henceforth, process). (The third dimension referred to above, namely understanding of the social institutions of science, is not dealt with in this study.) We shall describe briefly the sorts of questions that were used to measure understanding on each of these dimensions. A full list of all the relevant items and the results is provided in Appendix 2.

In the domain of knowledge, our aim has been to assess levels of acquaintance with the factual and theoretical content of science. After careful piloting, we established a suitable level of average difficulty for items in this area; and in addition, we decided upon a ‘true/false’ quiz as the most appropriate format for the majority of the items. Our knowledge quiz comprises more than 20 simple propositions covering the fields of physics, chemistry, geology, and the bio-medical sciences. For example, respondents were asked to reply true/false/don’t know to the following propositions: ‘electrons are smaller than atoms’; ‘common table salt is made of calcium carbonate’; and ‘the earliest humans lived at the same time as the dinosaurs’. In addition to the quiz, several knowledge items were asked in non-quiz format. These included the much-publicized two-part question: first, ‘does the Earth go round the Sun, or does the Sun go round the Earth’; and (for those who state that the Earth goes round the Sun), ‘how long does it take for the Earth to go round the Sun: a day, a month, or a year?’

One or two of our knowledge items have been criticized on philosophical or technical grounds.7 In our view, most of these criticisms ignore the fact that the quiz items were designed explicitly for a general, non-technical audience that is unlikely to be troubled by sophisticated issues such as the relativity of motion in modern cosmology, or the non-localizability of the electron in modern atomic theory. In addition, of course, it is important to underline the fact that, from the psychometric point of view adopted here, no single quiz item has any particular significance in isolation from all the others. In fact, aggregation of the knowledge items yields a highly serviceable scale (see Appendix 2).

We turn next to measures of understanding of the processes of scientific inquiry. Here, we were able to build upon the earlier work of Miller. In particular, we adopted his two-part question: first, ‘would you say that you had a clear, a general or little sense of what it means to study something scientifically?’; and second (for those who answer ‘clear’ or ‘general’ only), ‘please state in your own words what it means to study something scientifically’. The resulting statements were recorded verbatim and then categorized according to the following criteria (actual results are given in brackets):

1. Reference to science as a process of theory construction and hypothesis testing (3%)
2. Reference to experimentation or controlled testing, without mention of theory (11%)
3. Reference to fact-gathering, or mention of concrete scientific procedures such as looking down a microscope (43%)
4. Not answered/don’t know (43%)

To judge from these results, very few of our respondents had more than the vaguest of ideas about what it means to study something scientifically. However, this conclusion should be qualified in two ways. First, the question itself is extremely difficult. The task of stating clearly and concisely in one’s own words what it means to study something scientifically is, to say the least, non-trivial. Arguably, the question measures linguistic skills as much as scientific understanding; certainly, it ignores the possibility of tacit understanding of the processes of scientific inquiry. Second, the criteria for coding the open responses clearly reflect a particular, hypothetico-deductive view of scientific method. While it may be the case that such a view is commonplace amongst scientists, it is nonetheless open to dispute; and it must be observed that the choice of a radically different view could conceivably alter the results.

For these and other reasons, we devised a number of ‘closed’ questions that required respondents only to select rather than to state their preferred responses (see Appendix 2). Comparison of the results on the open and closed questions confirms our doubts about the reliability of the open item described above. Thus, while fewer than 14% of respondents included reference to experiments in response to the open-ended item, no less than 56% opted for the experimental approach when given a choice between alternative methods of investigating a medical problem. Of course, the latter figure may reflect public familiarity with clinical drug trials as well as public awareness of the role of experiment in science (of this, more later). However, at face value these results confirm the intuitively plausible idea that many respondents possessed a considerable amount of tacit understanding of the processes of scientific inquiry. In all, we fielded seven different questions on process. These covered subjects such as the status of scientific theories, the role of experiment, and the relationship between science and technology. As with the knowledge items, the results of these questions were aggregated into a scale (for further details, see Appendix 2).

The decision to measure scientific understanding on two principal dimensions rests on the assumption that knowledge of the factual and theoretical contents of science, on the one hand, and knowledge of the processes of scientific inquiry, on the other, constitute two related elements within a larger construct. This assumption may be tested by comparing the knowledge and process scales that have now been described. Such comparison reveals that the two scales are indeed closely associated ($r = 0.68$). This association justifies the further aggregation of the two scales into a single scale of 27 items (Cronbach’s alpha reliability coefficient = 0.84). It is this larger scientific understanding scale that will be used for purposes of further analysis.

2.3. The validity of the understanding measure

The results summarized above confirm that our understanding scale is statistically reliable. Whether or not it is statistically valid is best judged by comparing it with other variables. A priori, we would expect scientific understanding to be correlated with a variety of socio-demographic variables, including age, gender, social class and
educational level; equally, we would expect it to be correlated with other, more subject-specific variables, such as interest in science. In fact, all the expected relationships hold. Among our respondents younger people tend to know more than older people \((r = 0.34)\), males tend to know more than females \((r = 0.26)\), middle-class people tend to know more than working class people \((r = 0.45)\), and people of higher educational level tend to know more than people of lower educational level \((r = 0.58)\).

We began our survey by asking respondents how interested they were in a variety of issues in the news: new medical discoveries; new scientific discoveries; new inventions and technologies; new films; sports in the news; and politics. As we might have expected, self-reported interest in medicine ranked highest. More surprisingly, perhaps, self-reported interest in both science and technology ranked well ahead of self-reported interest in the three non-scientific issues. Figure 1 compares scientific understanding with these data on scientific interest. As we would expect, self-reported interest in science and technology is strongly related to scientific understanding \((\text{science, } r = 0.38; \text{technology, } r = 0.39\) (Figure 1).
technology, \( r=0.34 \)). However, the relationship between medicine and scientific understanding is much weaker \( (r=0.13) \). This is because interest levels in the case of medicine are so very high; as a result, variance in medical interest is low, and we would not expect to find close correlations with other variables. In short, virtually everyone in our sample is interested in medicine, irrespective of how closely acquainted they may be with science.

3. Social representations of science

We have now provided grounds for believing that the understanding measure is valid. Further confirmation would be provided from more extensive use of the understanding variable for analytical purposes. In the remainder of this paper, we provide this confirmation by putting the understanding measure to work as an analytical tool in the exploration of social representations of science.

3.1. The scope of the scientific enterprise

From the point of view of professional scientists in the English-speaking world, the boundary separating scientific from non-scientific subjects would appear to be reasonably clear. Admittedly, there are perennial debates about the scientific status of so-called 'social sciences' such as psychology and sociology; and of course there are even more intractable arguments about so-called 'para-scientific' subjects such as parapsychology. In general, however, Anglo-saxon cultures make clear distinctions between scientific and non-scientific subjects; and within the domain of the sciences, they retain a commitment to the positivist hierarchy from mathematics and physics, through chemistry and geology, and on to biology and the medical sciences.

This being the case, it is of some interest to inquire how the general public views the landscape of science. With this question in mind, we fielded a series of items in which respondents were invited to estimate the scientific status of different disciplines. The disciplines offered were astrology, astronomy, biology, chemistry, economics, history, medicine, physics and psychology. To avoid ambiguities, each discipline was briefly defined; and for each, respondents chose among five answers, ranging from 'not at all scientific' to 'very scientific'. The results are shown in Figure 2. With the single and signal exception of medicine, this public ranking accords reasonably well with the professional, scientific ranking described above.

Presented merely as aggregates, these rankings throw only a limited amount of light upon public representations of science. Armed with the scientific understanding variable, however, it is possible to resolve significant differences within the rankings. Figure 3 compares the rankings of the nine disciplines with scientific understanding. Three potentially significant findings emerge from this exercise: first, with the singular exception of medicine the order of ranking of the disciplines is reasonably well conserved across all four levels of understanding; second, the range of the rankings increases with increasing levels of understanding; and third, whereas the spread of rankings at the bottom level of understanding is more-or-less continuous, that at the top is clearly discontinuous—there is a cluster of high-ranking disciplines (astronomy, biology, chemistry and physics), a single middle-ranking discipline (psychology), and a cluster of low-ranking disciplines (astrology, economics and history).
Public understanding of science in Britain

These results suggest that respondents with lower levels of scientific understanding tend not to draw clear distinctions between subjects: for them, most subjects are regarded as being at least somewhat scientific; and none (excepting perhaps medicine alone) is regarded as being really very scientific. By contrast, respondents with higher levels of understanding tend to draw rather firmer distinctions between subjects. Certainly, there is no sharp boundary separating two distinct views; rather, there is a steady trend from lesser to greater levels of discrimination. In other words, with increased levels of scientific understanding (as we have chosen to define and measure it), there comes an increased tendency to discriminate clearly between scientific and non-scientific subjects. Needless to say, this is precisely what we would expect if the understanding variable were providing a valid measure of respondents' familiarity with matters scientific.

A pattern of results very similar to these has been obtained by Boy in a study of French public perceptions of science. Boy used a slightly different range of disciplines;
and instead of a direct measure of scientific understanding he used educational level. However, he too found a tendency for disciplines to be ranked in the same way across all educational levels; and he too found an increasingly sharp three-fold grouping at the higher end of the spectrum, with separate clusters of scientific disciplines (e.g., biology and physics), intermediate disciplines (e.g., meteorology and psychology) and non-scientific disciplines (e.g., astrology and history).

Boy interpreted these results in terms of Moscovici's notion of a social representation. According to Boy, there may be two different social representations of science at work in French culture: a 'popular representation', in which science is a poorly defined area of indefinite extent; and a 'cultivated representation', in which science is a well-bounded area of definite extent. Boy uses these contrasting representations (which he suggests are extremes of a continuum, rather than discrete entities) to interpret a number of features of French public perceptions of science. He notes, for example, that biology is accorded higher scientific status among less well-educated groups, suggesting in passing that this may be due to the overesteeem given to medical science.
which is especially obvious in these groups. Boy does not reveal his sources of evidence for this last statement. However, our results appear to support his interpretation. Adopting Boy's terminology, we shall suggest that medical science may occupy a central, paradigmatic role within the popular representation of science in British culture.

3.2. The paradigmatic role of medicine

At several points in the account thus far, we have had occasion to comment upon public perceptions of medical science. We have noted, for example, that medical science ranks top in terms of self-reported interest, and that (unlike interest in science and technology) medical interest holds up well even among respondents whose scientific understanding is very low. Again, we have observed that medical science ranks top in terms of perceived scientific status. When this result is analysed in terms of scientific understanding, it emerges that medical science breaks the general rule of the preservation of the order of ranking of disciplines across different levels of scientific understanding; respondents with lower levels of scientific understanding tend to accord medical science a relatively much higher scientific status (see Figure 3).

Taken together, this evidence suggests that medical science occupies a special place in social representations of science, and particularly in what Boy terms the popular as contrasted with the cultivated representation of science. For virtually everyone, medical research is the most interesting branch of science; but for those whose acquaintance with matters scientific is fairly slight, it seems to occupy a truly dominant position. It is judged to be not merely far more interesting, but also far more scientific than anything else. For many of our respondents, it is as if science as a whole were being perceived in terms of what was known about medical science. In other words, it is as if medical science were acting as a model or paradigm for the scientific enterprise.

There are two further pieces of evidence that provide some support for this tentative hypothesis concerning the paradigmatic role of medical science within the popular representation of science. The first comes from the results of the two-part question about the nature of science, which have already been described. All respondents were asked whether they had a clear, a general or a poor understanding of what it means to study something scientifically; and then those who claimed to have either a clear or a general sense were asked to state in their own words what this was. In the event, 1232 respondents were asked the second, open-ended part of this question. Among these respondents, 242 (20%) had recourse to one or more concrete examples to illustrate their answers. (If this figure seems low, it should be recalled that these examples were entirely unsolicited.) Revealingly, more than half (54%) of all these examples were medical. Searching for examples with which to answer a difficult question, respondents will presumably have grasped at whatever fell most readily to hand. It is surely significant that medical science fell to hand more often than the whole of the rest of science and technology put together.

The second piece of additional evidence concerning the paradigmatic role of medical science within the popular representation of science comes from a completely different direction. It will be recalled that we used a closed response question involving a medical example to investigate understanding of the role of experiment in science. Of course, the aim of this question was not specifically medical. In fact, we developed two versions of the question, one medical and the other metallurgical. In the event, we fielded only the medical version in our British survey. However, a few months later
one of us assisted in the design of another survey for the European Commission (EC). We suggested including the experiment question, and this time we proposed a "split half" design involving the random division of respondents into two groups each of which would receive a different version of the question. The EC survey was fielded through the 'Eurobarometer' survey instrument in all twelve member states of the European Community in the spring of 1989, and the results of this little 'experiment on experiment' are shown in Figure 4. Surprisingly, it emerges that substantially more respondents choose the experimental option in the medical version of the question as do so in the metallurgical version.

Two possible explanations of this interesting difference are worth consideration.

![Figure 4. Results of the experiment question included in the spring 1989 Eurobarometer survey. The survey included two different versions of the experiment question first used in our 1988 ESRC-funded survey in Britain. The first version was identical to that used in the 1988 survey (see section A2.2, item (b)). The second version was as follows: Suppose a metal used to make a machine is suspected of being the cause of repeated breakages. On this card are three different ways scientists might use to investigate the problem. Which one do you think scientists would be most likely to use? (1) Talk to machinists to get their opinions; (2) Use their knowledge of metallurgy to decide how good the metal is; (3) make machines of different metals. Then compare how often they break; (4) Don't know. The sample was divided randomly in two, and each half was given one version of the question. The figure shows the percentage of respondents who opted for each of the four response categories offered. Overall N= 1000.](image-url)
First, it is possible that respondents judged the two topics differently. For example, if respondents had judged metallurgical theory to be more advanced (and therefore more predictive) than medical theory, this might have led them to prefer the theoretical over the experimental option more often in the case of metallurgy. While this explanation is perfectly possible, however, it seems to us to be rather unlikely. For one thing, we doubt whether it is actually the case that metallurgical theory is more sophisticated than medical theory; and for another, we doubt whether it is justified to assume this level of sophistication in respondents' choices. A second, simpler and, we believe, far more plausible explanation for the result is that more respondents chose the experimental option in the case of medical science because more people are familiar with the conducting of clinical drug trials than with the experimental testing of metals. On this view, the reason why so many respondents opted for the experimental option in the case of the suspect heart drug was that they happened to know that this is precisely the sort of thing that medical researchers actually do.

If this is so, then the EC survey result has two interesting implications. First, it suggests that our intended measure of public understanding of the role of experiment in science may be less easy to interpret than we had assumed. For it appears that many of the respondents who chose the experimental option in our study may well have chosen differently had we only used a non-medical example; and this may mean that they did not possess a secure, context-independent concept of scientific experiment after all. Secondly, however, this result underscores the pre-eminent role of medicine in shaping public perceptions of science. In Britain and most other European countries, it seems that the general public is more familiar with medical than with other kinds of scientific experiments.

### 3.3. Medical science and the popular representation of science

The conclusion that medical science is more prominent in people's minds than other kinds of science is not, in itself, particularly surprising. After all, few things interest or concern people more than their own health; and this is reflected in the fact that medical stories make up a very large proportion of all science-related news and feature articles in the media. What we are suggesting, however, is not merely that medical science is prominent but rather that it is paradigmatic. By this, we mean that medical science may occupy a central and key position within the popular representation of science. In other words, what people know and feel about medicine may help to shape what they know and feel about science as a whole. This must be regarded as a tentative hypothesis at this stage; but it is a tentative hypothesis that has a number of interesting implications, at least some of which may be explored through our survey data.

Medical science is a rather distinctive branch of science. If medical science were paradigmatic within the popular representation of science, then we might expect some of medicine's distinctive attributes to be generalized within the popular representation. Three distinctive attributes of medical science are worthy of mention here: first, it is primarily an applied science; second, its applications are very generally regarded as being of great public benefit; and third, many of its practitioners are also clinicians who personally deliver the fruits of their research to patients.

Consider first the fact that medical science is applied. If medical science is paradigmatic for the popular representation of science, we might therefore expect this representation to include a broadly utilitarian view of science as a whole. In fact, our
British survey supports this conclusion. Respondents were asked to say whether in their view the main aim of science is either, 'to learn more about the world', or 'to develop new and useful products'. Overall, 36% said that the main aim of science is to learn more about the world, while 56% said that the main aim of science is to develop new and useful products. Figure 5 compares these results with scientific understanding. Clearly, the utilitarian view predominates among those with lower levels of scientific understanding. Only among those with the highest levels of scientific understanding does the non-utilitarian view of science overtake the utilitarian. This is precisely what we would expect if medical science were paradigmatic for the popular representation of science.

Public attitudes towards science are also consistent with our thesis. For in spite of the large number of social and environmental problems with which science is often associated, most surveys continue to report a generally very positive and supportive attitude towards science and technology on the part of the public. Our survey shows that this positive attitude characterizes even those sections of the British public which have relatively low levels of scientific understanding. It will be recalled that among these sections of the public, self-reported interest in 'new scientific discoveries' and 'new inventions and technologies' are both relatively low, but self-reported interest in

![Figure 5. The aims of science by understanding. The y axis gives the percentage of respondents opting for particular answers to the question: 'What do you think is the main aim of science: either (1) to learn more about the world? or (2) to develop new and useful products?' N = 2009.](http://pus.sagepub.com)
‘new medical discoveries’ is high. Once again, therefore, we have a pattern of results that is fully consistent with a paradigmatic role for medical science.

Finally, there remains the question of public attitudes towards scientists. As we have already stated, medical science and clinical practice are not clearly distinguished by people with generally lower levels of scientific understanding. This being the case, we might expect the generally positive public image of the physician to be extended to include the medical scientist; and this being so, we might also expect the positive image of the medical scientist to be extended to include scientists in general. Boy notes of his ‘popular representation’ of science in French culture that it incorporates the image of the devoted scientist dedicated to the service of humanity.15 We have not explored public attitudes towards scientists directly in our survey. However, we have explored a related issue, namely public attitudes towards disagreements between scientists; and the results generally support the notion of a very positive image of scientists within the popular representation of science.

We presented our respondents with two quite different issues about which scientists are in disagreement: the question of the extent to which low-level radiation is harmful; and the question of why the dinosaurs became extinct. In each case, respondents were invited to select one from among four possible reasons for the disagreement, namely: no-one has all the facts; scientists interpret the facts using different theories; scientists have different political beliefs; and scientists have different personal and career interests. The reason for choosing the two examples was that one of them is socially and politically contentious and the other is not. The reason for choosing the four alternative explanations was that two of them involve ‘internal’, scientific factors and two of them involve ‘external’, personal and social factors.

Thus, our questions were intended to explore the extent of public confidence in scientists. What we half-expected to find was that many more respondents would opt for social or political explanations in the radiation example, thereby expressing less trust or confidence in the scientists involved. In the event, there was a small difference in this direction; but in both cases, the vast majority of respondents preferred to explain the controversy in terms of factual or theoretical disagreements rather than personal or ideological differences (see Figure 6). This refusal to adopt a cynical view of scientists, even in socially and politically sensitive areas, is consistent with our suggestion about the paradigmatic role of medicine in the popular representation of science.

4. Conclusion

We have argued that it is possible to construct a reliable and valid multi-item scalar measure of scientific understanding, and that such a measure may assist in the analysis of the relationship between science and the public. In our survey study, the understanding measure discriminates successfully between sub-groups of our sample by interest in science, by views on the scope and the aims of science, and by many other variables. In fact, it is the discriminatory power of the understanding measure that makes it so useful in the analysis of public perceptions of science; more useful, for example, than the general measures of educational attainment which have been employed by others for similar purposes. For this reason, it is desirable that future survey studies in our field should continue to incorporate measures of scientific understanding.
1. Durant, G. Evans and G. Thomas. Interpretation of expert disagreements. Respondents were told that there are issues on which scientists do not agree. One is the question of the extent to which low-level radiation is harmful to health, and another is the question of why the dinosaurs became extinct. In each case, respondents were invited to select one from among four possible explanations for these disagreements. The explanations offered were: (1) no-one has all the facts; (2) scientists interpret the facts using different theories; (3) scientists have different political beliefs; and (4) scientists have different personal and career interests. The x axis gives the four offered explanations, and the y axis gives the percentage of respondents who opted for particular explanations in each of the two cases. N = 2009.

We started this paper by defending the attempt to measure the nature and extent of public understanding of science against criticisms based upon a rejection of the deficit model of public understanding of science. However, we have ended by using measures of the nature and extent of public understanding of science to build a case for the paradigmatic status of medical science within the popular representation of science in Britain. There is a certain irony here. For critics of the deficit model insist that one of its fatal weaknesses is its attempt to force public perceptions of science into the mould of professional, scientific perceptions. Yet our argument suggests that there may be significant and systematic differences between popular and professional representations of science. For one thing is certain: it is no part of the professional representation of science to regard medical science in the English-speaking world as paradigmatic for the whole of science.
The conclusion that medical science occupies a central place within the popular representation of science should be regarded as provisional at this stage. Further work is needed to confirm it, and to clarify its implications. It will be important, for example, to explore in more detail the nature of public images of the scientist in order to see how far they conform to a medical model. In the meantime, however, we believe we have demonstrated not only that the public understanding of science can be measured, but also that such measurement can assist greatly in the analysis of the place of science in popular culture.

Appendix 1. About the survey

The survey is a joint Science Museum/Oxford University Department for Continuing Education/Social and Community Planning Research (SCRP) project funded by the Economic and Social Research Council.

The sample was designed to be representative of the adult population of Britain (those aged 18 and over). The sampling method involved four separate stages of selection, using the electoral register as a sampling frame. The first stage was the selection of 130 parliamentary constituencies with the probability proportionate to electorate. Prior to selection, constituencies were allocated to strata according to region and population density. Within each stratum they were then listed, in descending order, according to the proportion of the population with a degree, professional or vocational qualification. The second stage was the selection within each constituency of one polling district, again with probability proportionate to electorate. The third stage was the selection of 23 addresses from the electoral register of each polling district. The selection was made with probability proportionate to the number of electors registered at the address. Thus a total of 2990 addresses was selected. The fourth and final stage involved the selection of one adult at each address by means of a selection grid.

Fieldwork was carried out by SCPR interviewers during June and July 1988. Interviews were conducted in respondents' homes. The response rate, after excluding a small number of ineligible addresses (92) from the base, was 69%. A total of 2009 interviews was achieved.

Appendix 2. The understanding measures

A2.1. Measures of scientific knowledge

<table>
<thead>
<tr>
<th></th>
<th>True</th>
<th>False</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>The centre of the Earth is very hot.</td>
<td>86</td>
<td>4</td>
</tr>
<tr>
<td>(b)</td>
<td>All insects have eight legs.</td>
<td>8</td>
<td>84</td>
</tr>
<tr>
<td>(c)</td>
<td>The oxygen we breathe comes from plants.</td>
<td>60</td>
<td>28</td>
</tr>
<tr>
<td>(d)</td>
<td>Radioactive milk can be made safe by boiling it.</td>
<td>13</td>
<td>65</td>
</tr>
<tr>
<td>(e)</td>
<td>Lasers work by focusing sound waves.</td>
<td>20</td>
<td>42</td>
</tr>
</tbody>
</table>
(f) Sunlight can cause skin cancer. 94 3 3
(g) Hot air rises. 97 1 2
(h) The liver makes urine. 25 53 21
(i) Electrons are smaller than atoms. 31 24 45
(j) The continents are moving slowly about on the surface of the Earth. 72 8 20
(k) The future children of a body-builder will inherit the benefits of his training. 13 77 11
(l) Diamonds are made of carbon. 59 16 25
(m) It is the father’s gene which decides whether the baby is a boy or a girl. 51 26 23
(n) Antibiotics kill viruses as well as bacteria. 55 29 17
(o) Natural vitamins are better for you than laboratory made ones. 70 18 13
(p) Common table salt is made of calcium carbonate. 37 31 32
(q) The earliest humans lived at the same time as the dinosaurs. 32 46 22
(r) Which travels faster—light or sound?
   Light travels faster 75
   Sound travels faster 19
   Don’t know 7
(s) Nuclear power stations produce radioactivity. Is all radioactivity man-made or does some radioactivity occur naturally?
   All man-made 9
   Some naturally occurring 74
   Don’t know 16
(t) Of the following things (a) which is the largest? (b) which is the next largest? (c) which is the smallest?

<table>
<thead>
<tr>
<th></th>
<th>Largest</th>
<th>Next largest</th>
<th>Smallest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar system</td>
<td>14</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Galaxy</td>
<td>13</td>
<td>36</td>
<td>4</td>
</tr>
<tr>
<td>Earth</td>
<td>7</td>
<td>6</td>
<td>72</td>
</tr>
<tr>
<td>Universe</td>
<td>54</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Sun</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Don’t know</td>
<td>7</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>
(u) Does the Earth go round the Sun or the Sun go round the Earth?
Earth round Sun 63
Sun round Earth 30
Don't know 7

(v) If the Earth goes round the Sun at (u), how long does it take?
One day 16
One month 2
One year 34
Don't know 10

(w) When scientists use the term DNA, do you think this is to do with the study of:
Stars 2
Rocks 2
Living things 43
Computers 7
Don't know 46

All scores are percentages, rounded to the nearest whole number. Questions (a)–(s), (u), (v), and (w) were scored 1 point for a correct answer and 0 for an incorrect or 'don't know'. Item (t) was scored 1 point for getting all three question parts correct and 0 for all other answers. The knowledge questions were subjected to principal components analysis, which revealed a single major dimension with no interpretable topic-specific or other minor dimensions.

A preliminary knowledge scale was constructed using all 23 questions. Cronbach's alpha reliability analysis revealed that items (b), (i) and (m) were not contributing to the reliability of the scale, and these were therefore removed. The resulting 20-item scale (the Oxford Scientific Knowledge Scale) has a Cronbach's alpha reliability coefficient of 0.81. The scale is normally distributed, with a mean score of 11.44 and a standard deviation of 4.15.

A2.2. Measures of understanding processes of scientific inquiry

(a) What does it mean to study something scientifically? Answers including reference to:
Theory construction 3
Experimental method 11
Other answers 43
Don't know/not answered 43

(b) Suppose a drug used to treat high blood pressure is suspected of not working well. On this card are three different ways scientists might use to investigate the problem. Which one do you think scientists would be most likely to use?
(i) Talk to patients to get their opinions 13
(ii) Use their knowledge of medicine to decide how good the drug is 27
(iii) Give the drug to some patients but not to others. Then compare what happens to each group 56
(iv) Don’t know 4

c) When scientists talk about Einstein’s theory of relativity, are scientists talking about:
   (i) A hunch or idea 11
   (ii) A well established explanation 33
   (iii) A proven fact 39
   (iv) Don’t know 16

d) And when they talk about Darwin’s theory of evolution, are scientists talking about:
   (i) A hunch or idea 20
   (ii) A well established explanation 45
   (iii) A proven fact 21
   (iv) Don’t know 15

e) Doctors tell a couple that their genetic make-up means that they’ve got a one in four chance of having a child with an inherited disease. Does this mean that:

   (i) If they have only 3 children, none will have the illness?  Yes 5  No 84  Don’t know 11
   (ii) If their first child has the illness the next 3 will not?  Yes 9  No 80  Don’t know 10
   (iii) Each of the couple’s children has the same risk of suffering from the illness?  Yes 82  No 10  Don’t know 8
   (iv) If their first 3 children are healthy, the fourth will have the illness?  Yes 9  No 80  Don’t know 11

f) All of today’s scientific theories will still be accepted in a hundred year’s time.
   Agree strongly 7
   Agree slightly 17
   Neither agree or disagree 14
   Disagree slightly 30
   Disagree strongly 25
   Don’t know 7

g) New technology does not depend on basic scientific research.
   Agree strongly 4
   Agree slightly 22
   Neither agree nor disagree 17
   Disagree slightly 29
   Disagree strongly 17
   Don’t know 12
All scores are percentages, rounded to the nearest whole number. The final process scale was constructed using all seven questions. Answers to question (a) were coded into four categories: (i) answers referring to science as a process of theory construction and hypothesis testing; (ii) answers referring to the notion of experimentation, but not mentioning the testing of theories or hypotheses; (iii) other, often rather vague answers referring to science as a process of fact gathering, or mentioning concrete scientific procedures (e.g., looking down a microscope); and (iv) respondents who did not qualify for the question, or who when asked replied 'don't know'. These categories were used as a four point scale, with category (i) scoring 3 points and category (iv) scoring 0. In question (b), respondents choosing options (i) and (ii) or ‘don’t know’ scored 0 and those choosing option (iii) scored 1. In questions (c) and (d), respondents choosing options (i) and (iii) or ‘don’t know’ scored 0, and those choosing option (ii) scored 1. In question (e), respondents who stated that option (iii) was correct and that all other options were incorrect scored 1 (the number scoring 1 on this criterion = 66%). In questions (f) and (g), those disagreeing with the propositions scored 1.

A principal components analysis of the process measures showed them to possess only a single major dimension. The process scale has a maximum score of 9 and a minimum score of 0. The mean score is 3.76, and Cronbach’s alpha reliability coefficient is 0.61.

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