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A Sociology of Expectations: Retrospecting Prospects and Prospecting Retrospects

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Abstract

Future expectations and promise are crucial to providing the dynamism and momentum upon which so many ventures in science and technology depend. This is especially the case for pre-market applications where practical utility and value has yet to be demonstrated and where investment must be sustained. For instance, clinical biotechnology (including a wide range of genetic therapeutic and engineering applications) has been at the centre of ferocious debates about whether or not promises and expectations will be realised. In some cases, the failure of expectations has severely damaged the reputation and credibility of professions, institutions and industry. The need for a better analytical understanding of the dynamics of expectations in innovation is both necessary and timely.

This paper develops the basis for a sociology of expectations, drawing on recent writing within Science and Technology Studies (STS) and case studies of biotechnology innovation. In particular, we offer a model for understanding how expectations will predictably vary according to some key parameters. Such factors include the degree to which technologies and innovation relationships are either relatively established or newly emergent. Expectations will also vary according to actors' relative closeness and involvement in knowledge production itself. The paper proceeds by analysing the way expectations in clinical biotechnology have changed over time. That is, we compare the way the future was once represented with the way it has been represented more recently. The paper concludes by offering a means by which it is possible to map or model the situatedness of expectations.

Introduction

This paper offers a critical analysis of the role of expectations in innovation dynamics, and in particular, draws on accounts of changing expectations in the fields of health and life science. Changes in expectations, occurring over time, present Science and Technology Studies scholarship with the opportunity to glimpse the way actors vary their engagement with the future according to shifting demands and uncertainties. Future orientation can be understood in relation to a range of criteria including:

- Differing degrees of technical novelty or the extent to which an innovation is understood as either relatively new or established.
- Organisational uncertainties which themselves generate the demand for different kinds of future oriented language, discourse, motifs and temporal abstraction.
- The differing location of relevant actors within a developing network of relationships involving primary researchers, publics, NGOs, policy and potential users, etc.

Conceptually, this paper explores the implications for technology and knowledge of newly emerging approaches to the sociology of futures and anticipation. In general terms, *Fashioning the Future*, the title of the 2001 conference for the Society for the Social Study of Science, at which this paper was first presented, attests to the growing intellectual interest in this area. More specifically, the recent volume *Contested Futures* sought to bring together a number of STS reflections on the dynamics and significance of future oriented coordination.¹ These and other developments, emphasise the need for scholarship to engage with the future as an analytical object, and not simply a neutral temporal space into which objective expectations can be projected. In particular, they highlight the need to shift the analytical angle from *looking into* the future to *looking at* the future, or how the future is mobilised in real time to marshal resources, coordinate activities and manage uncertainty.

The health and life sciences are populated with innovation concepts whose associated promise has shifted in emphasis over the course of the last decade or more, often between extreme revolutionary potential on the one hand and despairing disappointment on the other. New and emerging aspects of biotechnology commonly exhibit intense and competing discussions about their future promise. Such language is a particularly important organising dynamic in these areas because so many of these fields are yet to see products through to actual clinical use. When examined over time rather than at any single moment in time, this 'topology of the future' becomes even more complex. As new activities and 'cutting edge' industries surge forward, just as many seem to fall away from view as initial investments dwindle and inertia sets in. In one way or another then, the characteristics of expectations alter according to whether a field is newly emerging, as is the case with embryonic stem cells for example, or whether an innovation concept has a longer history, perhaps illustrated by gene therapy for instance. Such variations, in addition to others, are inextricably linked to distinctive forms of future oriented language and discourse.

Our suggestion here is that significant patterns can be observed when we compare real-time current expectations with memories of former expectations. Such changing expectations, evident throughout accounts of life science innovation, can be understood in two distinguishable ways by which people interpret expectations and change. The first of these 'interpretative registers' refers to the way the future was once represented, as distinct from the way it is currently represented. This process of recollecting past futures we have called *Retrospecting Prospects*, or people's memories of the future. The second register refers to what people do in the present with these recollections. That is, the uses that people have for these memories by redeploing them to manage or engage with the future. This second activity we have called *Prospecting Retrospects*, whereby past futures are incorporated into the real-time constructions of future presents:

- ***Retrospecting Prospects***: the recollection of past futures or how the future was once represented.
- ***Prospecting Retrospects***: how these prospects are deployed in the real-time now, to construct futures.

In developing our argument, we will begin by highlighting some nascent critiques of expectations within Science and Technology Studies and how these might be applied to an analysis of changing expectations. In so doing, we want to prepare the ground for an analytical framework within which to situate actors' orientation to the future and the past, their acts of *Retrospecting Prospects* and *Prospecting Retrospects*. In the central section of the paper, we develop this discussion with a case study analysis in biotechnology and medical innovation, drawing on primary research sponsored under the Innovative Health Technologies programme of the UK Economic and Social Research Council. The case study itself is xenotransplantation (XT), the use of nonhuman tissues and organs in human transplant surgery, although respondents in this research routinely make comparisons across and between numerous areas of health sciences innovation. It is these comparisons across time and across different cases that we are particularly interested in here. The case study, we suggest, is illustrative of the kinds of experiences that commonly characterise the relationships between technologies and future oriented activities. In the final part of the paper, we will endeavour to offer some basis for mapping or modelling expectations over time and in relation to the changing needs of innovation actors. Such an approach, we argue, is necessary if STS and policy alike are to make intelligent sense of past and present expectations.

Sociologies of Prospective Techno-Science

A number of social theorists and STS scholars have begun to examine some of the complex questions and analytical dilemmas buried within the notion of future-orientation. Not least, contributors to *Contested Futures*² sought to engage with the future as an object of critique in its own right, refraining entirely from attempts to predict or envisage the future of today's emerging innovations. In so doing, the analytical challenge has been to produce a dereified account of the future by drawing on a detailed examination of the forms of action and agency through which the future is both performed (as a temporal representation) and colonised (as a spatial and temporal locus).

Futures, like time itself and many other temporal abstractions, present acute analytical difficulties when we try to separate out the many varied meanings in play.³ The present both creates a demand for future and past engagement whilst being only available to us imaginatively through histories and projections. As Adam⁴ contends '...the locus of reality is the present... . the past and the future... are constantly created and recreated in the present. The real past, just like the real future, is unobtainable for us, but through mind is open to us in the present'. However, that such temporal abstractions play a hugely powerful role in both socio-cultural life and technoscience can be in no doubt whatsoever.

Anthony Giddens⁵ has argued, somewhat provocatively,⁵ that contemporary culture is marked by a much more intense future-orientation than before. The premodern relationship to the future is dominated by a theistic orientation toward conserving the present in the future, preserving the natural order of things. The modern world sees a substitution of divine agency by human agency and with it the substitution of conservation by innovation. This dwelling in the future is in part a consequence of the many competitive pressures forcing social action to increasingly occupy future positions of advantage, in addition to those of the present. The more acute the competition, the more urgent is the requirement to push the horizon of competitive action further and further into the future, beyond the gaze of one's competitors. That is, the present becomes increasingly subject to the pressures of compression, where units of time and action are reduced to smaller fractional divisions, and where present (and near present) markets become saturated. An overwhelmed economic environment forces the time horizon of rivalry further and further into the speculative future. These near-term tendencies towards acceleration lead to correspondingly greater pressures on future-engagement, the attempt to be always one step ahead.

The changing temporal characteristics of duration also couples up with more general contemporary dynamics of speed and velocity. Paul Virilio observes that 'if time is money, then speed is power'.⁶ This, in turn, pushes the horizon of competitive action further and further into the speculative future. The fetishisation of the new, and shortening time frames of built-in obsolescence, increasingly focuses attention on emerging rather than established routines and habits.⁷ In more fiscal economic terms, the commodification of time (time = money) has been translated into a commodification of the future (uncolonised future time = future money wasted). Emphasis has therefore transferred from a fetishisation of the new, to a fetishisation of the soon to be and a corresponding attunement to the exploitation of emerging or future opportunities rather than established routines and habits. For instance, the 'just in time' (JIT) economy is real-time evidence of this temporal shift in balance from the past to the present and into the future. Anything static is simply absorbing resources (space and revenues) until it can be handed on at a higher value. The further into the past one acquired a commodity, the greater are the costs (processing, storage, etc), until investment is recouped. Success depends on shortening these time frames and, if possible, projecting them into the future.

The resulting contestation around future-dwelling makes even more apparent the attendant dual discourses of risk and opportunity. Far from reducing uncertainty, this intensifying engagement with the future leads to a shared escalation in uncertainty. In this way, the production of information about the future becomes part of the problem rather than a solution to it in that the '...very development of the knowledge actually makes the future more rather than less opaque... ' .⁸ Those instruments

devised to create knowledge about the future and to facilitate its better management (scenarios, foresight initiatives, statistical probabilities, futures assessments in financial services, etc) have a tendency to confront us in the present with glaring uncertainties, and not least when outcomes routinely deviate from what has been predicted.

To some extent, this dynamic between future colonisation and a growing awareness of future risk, accounts for the demise of the quantitative predictive instruments of the 1970s and 1980s.⁹ Without uniformly replacing such techniques, policy has come to rely on more qualitative and collective accounts of the future derived from scenarios, delphi exercises and foresight, though still within a normatively predictive or extrapolative paradigm. STS on the other hand, recognising the capacity of such instruments to shape science and innovation policy, has begun to develop an analytical vocabulary for understanding these complex interactions between tools of prediction, discourses of the future and the shaping of the present.

The development of a nascent STS analytical framework focused on such issues has, itself, exhibited some tensions. Scholarship has, for instance, concerned itself with the relationships and contrasts between rhetorical or linguistic representations of the future and limits to the actual materialisation of these representations. Wyatt's¹⁰ discussion of metaphor, in future discourse about the Internet, emphasises the constitutive power of language in shaping and reshaping the political organisation of ICTs. For instance, Al Gore's portrayal of the Internet as the 'information superhighway', whilst now sounding much like a cliché, actually assumed a significant popular valency. It provided momentum by popularising a linear future necessity, a techno-metaphorical 'conduit' to the future of the Internet itself. Similarly, Mulkey's¹¹ account of rhetorics of hope and fear in parliamentary debates about embryology demonstrated the apparent unassailability of certain representations of the future, especially those that evoked 'hope'.

The background to much of this is the discursive abstraction of 'Western progress' itself.¹² Van Lente draws on McGee's notion of the 'idiograph' in his discussion of the way normative technological progress serves as an incredibly flexible shared conviction, 'a high order abstraction, representing collective commitment to a particular but equivocal and ill-defined normative goal'.¹³ Progress is as culturally cherished as other idiographic formations like justice, freedom and democracy. When evoked, it seems to have a life of its own, an autonomous force that appears to hover outside of agency and action. Van Lente's objective is to dereify the future by tracing the chains of action and agency by which abstractions like progress are sustained. He does this by focussing on technological promise, a tacit contractual language that has the capability to '...mobilise attention, guide efforts and legitimate actions'.¹⁴

Now whilst, representations of the future have a far-reaching effect on the shaping of technology and knowledge, they must be analytically distinguished from actual events or effects themselves. Simply because the future is represented in a certain way, it does not follow that techno-social arrangements will uniformly concur with the futures idealised for them. Far from it. Brown¹⁵ focuses on the metaphor of the 'breakthrough', ever-present in popular accounts of science and medicine, and yet entirely

recent, confined exclusively to the latter half of the C20th. Whilst uniformly pervasive, the breakthrough motif highlights acute ambivalence – after all, the tacit promise contained within a breakthrough has all too often failed to materialise. In this way, the discursive shaping of the future highlights limitations when future promises encounter resistance from recalcitrant materials (see some versions of Actor Network Theory¹⁶) or unimpressed publics and professionals (critical accounts of the Public Understanding of Science¹⁷). Breakthrough is probably our most constant and pervasive discursive method for organising narratives about science, and yet it is also probably our most contested. Insofar as both scientific institutions and science journalists often present new knowledge in terms of the moment of breakthrough, they tend to misrepresent the extended processes and contingencies involved in the production and value of experimental findings and technological developments.

What our discussion so far hopefully has shown is that representations of the future are both potent resources in constituting the present and the future, but also highly unreliable – the past is littered with failed futures. Whilst expectations are largely discursive in character, they largely depend on material practice. However, relevant actors (scientific, technological, regulatory, etc) are not totally unaware of this phenomenon. We are all capable of listing a variety of past sociotechnical futures that were enthusiastically heralded and yet failed utterly to materialise. So, rather than simply consider the present uses of representations of the future, we want to embed these within what might be called meta-accounts of the past future. In other words, we wish to look at how actors contextualise their present futures in relation to their narratives of past futures, that is, their retrospections on futures that failed or succeeded in being realised.

Our analysis, then, turns to the relevance of future representations over time rather than their role at any single moment. This paper in particular seeks to address itself to retrospective (and prospective) analytical accounts of expectations. What, if anything, can be learnt by casting our minds back to expectations that were once held of the future or ‘when old technologies were new’ to borrow Marvin’s phrase.¹⁸ In many instances, and in accordance with technologically determinist discourse generally, there is an overwhelming tendency retrospectively to account for success or failure by referring to the properties of a technology or an artefact rather than other equally important factors. Just as common is the retrospective tendency to redefine prior expectations to fit in with the way things turned out. As Deuten and Rip¹⁹ observe, retrospective memories of the innovation process often forget many of the wide-ranging organisational and material contingencies upon which an artefact’s future once depended. Such contingencies are seen as peripheral ‘noise’ from which the ‘victorious’ artefactual hero emerges (p.70). The relationship between temporal/spatial distance and the retrospective tendency to underplay uncertainty maps onto similar discussion in STS by Collins²⁰ and MacKenzie²¹ and will be taken up again in the concluding discussion of this paper.

More usually, events unfold in ways not originally intended. So what, if anything, ask Geels and Smit²², can we learn from the failure of futures? Again, the explanation critiques fallacious technologically deterministic future visions which fail to take account of the co-evolution of complex techno-social relations. As observed earlier, contemporary images of the future overwhelmingly and erroneously emphasise the pivotal role of technology and gadgetry. The social, on the other hand, is the domain

where policy deals with 'impacts' and manages 'demand' or removes 'barriers' to the inevitable momentum of technology. Ironically, when futures fail, it is often because this very discourse of technologically-driven innovation change has prevailed. The lesson then lies in developing a more sophisticated appreciation of the co-evolution of the social and the technical. But such an appreciation will always hover between the requirement of innovation actors to inflate the promise of a field, and the need to intervene at key junctures where future rhetoric becomes damaging to reputations and capital investment.

The importance of these accounts is that they offer a way into thinking critically about one of innovation's most commonplace idioms, the future. The approach itself steps back somewhat from the predictive paradigm for the very reason that future-speculation might not be the best place for such an analysis to start. Instead, we might be better served by reflecting on the underlying strategies, metaphors and inconsistencies in play whenever the future is invoked. Having provided a brief introduction to the key analytical dimensions of future orientation, we now want to move to a discussion of changing expectations. This is a case study in the divergent ways old futures impact on new futures. The study itself touches on differing understandings of risk and opportunity in a health innovation, xenotransplantation, in addition to a number of other developments. How, we ask, do expectations vary across different constituencies and over time? Three main sources of data provide the evidence on which our discussion is based: secondary source material dating back two or more decades; in-depth interviews with individuals closely involved in xenotransplantation from public and private research, policy and clinical-surgical specialisms; focus groups with a range of publics. Probes for changes in expectations have been built into the fieldwork methodology in such a way as to explore patterns in the way expectations differ between respondent groups. In particular, we have encouraged respondents to reflect on how expectations might be seen to have changed over time, and also comparisons with other areas of health innovation (pharmacogenomics, embryonic and adult stem cells, gene therapy, etc).

Xenotransplantation (XT): A Case Study in Changing Expectations

There are a variety of reasons for looking at XT but for present purposes we are interested in the case because it entails significant changes in the expectations and promise surrounding the use of animals as a notionally convenient supply of donor tissues and cells. Most of these changing disputes tend to focus on several competing risk problems, principally:

- **Tissue rejection:** That human recipients and transgenic donor animals are not sufficiently similar enough immunologically - the risks of dissimilarity.
- **Exposure to transpecies disease:** Disease entities might jump from nonhuman 'donor' to human 'host' – the risks of similarity.

Risk identities always take shape in relation to temporal representations of change and the future. For instance, different risks are perceived and different identities expressed depending upon whether XT or transgenics are regarded as new and exotic or whether they can be viewed as benign incremental extensions of prior innovation (e.g. ancient methods of hybridisation, the use of pigs as food, the long-

standing use of pig heart valves). All of these kinds of representations situate cases like XT temporally in relation to different notions about newness or oldness. Chris Plein observed similar kinds of rhetorical moves in the shaping of US biotechnology policy.²³ What follows is a discussion of the way expectations of XT have changed over time (retrospecting prospects), followed by the future-oriented uses of these accounts (prospecting retrospects).

i. Retrospecting Prospects

Ten years or so ago, xenotransplantation was saturated with the kinds of promise and expectation that today seem, to many of our respondents, rather naïve. This sense of expectation followed quickly on the heels of fairly new developments in transgenics including gene restriction methods, splicing and insertion, etc. These approaches were seen to offer new possibilities for overcoming the immunological barriers of tissue rejection by 'marking' nonhuman tissues with the genetic attributes of the human immune system. All of our respondents are able to cast their minds back to those heady days when it seemed inevitable that transpecies transplantation for all kinds of tissue types would be relatively near term. So gene transfer technology had revived an existing innovation concept, the use of animal tissues, which had till then fallen into almost complete disrepute. In the early '90s, one of the key UK companies involved in the field even foresaw itself conducting clinical trials in 1996 on the basis of its announcements of breakthroughs in preclinical trial studies. Metaphors of immanent revolutionary breakthrough abounded during the early and mid 1990s.

The following extracts illustrate how these early expectations are now viewed by those who once held them. On the whole, all our respondents look back much less sanguinely on the futures they were once committed to.

Prominent researcher in both commercial and public sector:

(DCO) I've never really quite understood why people were so optimistic actually... colleagues... heart surgeons... [were] talking as if at age fifty you will automatically go in and have your pig heart put in... ... one of the commercial drivers was one of the bigger pharmaceutical companies ... because there was obviously an initial market for immunosuppressive drugs... . There's no real secret about that... it's a huge commercial market from their point of view... so a lot of money went in and I think the immunological expectations first of all were much harder than the reality has shown to be to be justified...

Renal surgeon with experience in immunological work on xenotransplantation:

(RQL) ... I think partly because there was a prominent scientist involved who raised expectations to an unrealistic level... and had this monocular view that... [transgenics] were going to solve it... clinical trials next week that sort of stuff; I think [pharma company] bought that thinking... I know it's being wise after the event... I and many of my colleagues did not realise it was going to be a long haul. You need belts and braces and several other things... on top of the expectations...

Commercial biotechnology researcher:

JHG: ...people thought that once hyperacute rejection was overcome, that the grafts would start looking like allotransplants [human-to-human transplantation], and that really hasn't panned out. There's other immune barriers that we need to by-pass.

Government Regulator:

KJD: there was a great deal of interest then in the possibility of whole organ [xenotransplantation]. It did seem to be just round the corner... we just had to get over hyperacute rejection and then it would all be plain sailing. And the make up of the [regulatory body]... we have a transplant surgeon... he is there because it's about whole organs, so we don't have neurologists or neurosurgeons on [the committee].

In the early days, I mean the kidney patients' associations were pushing very hard... once they became aware of the hurdles, they're expectations were rapidly lowered... they're now lay people with an interest who are better informed than most but who certainly aren't advocating xeno any more...

Now this narrative structure, of early promise to subsequent disappointment, is standard across most of these retrospective accounts. We also find wide-ranging assessments of how these promises took shape: the role of commercial pressures and monocular enthusiasts, the narrowing of the field around whole organs instead of cellular neural applications (this is the significance of the reference to neurologists in the above quote), the demise of expectations amongst potential users (kidney patients' associations), etc. There is clearly much to consider within these accounts, but the main dimension we would like to focus on are the way these memories are differently used in the constructions of future expectation. It is to these acts of prospective retrospection that we now turn.

ii. Prospecting Retrospects

As a matter of course during in-depth interviews, respondents routinely offer assessments of technological fields which today exhibit a forceful sense of expectation. These are technical fields that readily draw upon the language of breakthroughs and revolutionary future potential. For instance, in these accounts embryonic stem cells and pharmacogenomics are typically cast as important new arrivals in the anticipatory world of health innovation. In some cases, like that of stem cells, these are recent or emerging competitor technologies to transgenic xenotransplantation. But, of course, such competitors are no less liable to the same problematic outcomes. Our concern is to explore whether and how these recent innovations feature to similar narratives and representations. To this end, methodologically, we attempted to offer interview respondents the opportunity to apply the narrative structure – of early promise and subsequent disappointment – to these new developments.

Whilst there was some degree of agreement over applicability of this narrative to xenotransplantation, respondents differed over whether the narrative would apply to these newer research areas. In some cases, they describe how mistaken everyone was about xenotransplantation but then go on to champion the high expectations of stem cells.

Chair of a UK national kidney patients' organisation:

SRT: I think if you were to ask patients now, they don't think xenotransplantation is likely to happen in the foreseeable future. They think it's been overtaken by stem cell research. That's their concept. They don't see politicians ever having the guts to get it to happen, and they don't see the scientists being able to overcome the difficulties in the foreseeable future. You know, that is a patient's perception. I suppose their perception is that um to grow an organ within an animal and then to transplant it sounds more complex and more difficult than the concept of taking cells from a human and growing on...

Renal surgical research specialist again:

NB: with xenotransplantation ... lots of people got very depressed and left the whole thing. But with stem cells, it's almost as though we're right at the very beginning, and we haven't got into the thick of the problems.

RQL: Yes... the difference would be insofar as one can anticipate, there's no reason to imagine there are going to be the [same] biological obstacles ... that confront xenotransplantation. So I agree that it's early days; on the other hand, I think it will move quite quickly. I don't think; if you try to take your mind back to enthusiasm about xeno ten years' ago, and then all the obstacles we hit, I don't anticipate there's going to be the same level of obstacles... you're going against basic biology to stick a pig kidney into a human being; I mean it's an unnatural thing to do.

According to this interviewee, any problems for the newly emerging field of stem cells are going to be manageable and are already well known. These are technical matters that can be overcome because nature is pliant in the case of stem cells, though nature has turned out not to be so pliant in the case of xenotransplantation. The implication here is that stem cells will work because they are 'natural', whilst xenotransplantation will not work because it is 'unnatural'. In these terms, nature renders the standard narrative of optimism/obstruction inapplicable to stem cells.

Now others, particularly active researchers in biotechnology, think that history might be repeating itself. The following respondent has a lead role in Edinburgh's Roslin Institution, credited with initiating much of the current interest in cloning. The account is illustrative of those in our sample who, in most respects, think that the more significant problems are yet to be encountered by newly arrived initiatives such as stem cells.

Biotechnology researcher:

JJC: ... stem cells are going to get into the same wood, same brick walls as xenotransplantation... Both in efficacy... and safety... it's really strange to see this, and you can predict it... Obviously part of the issue here is people hawking up for money... the pressure is to hype...

... gene therapy's quite an example really... that's died pretty much a death... you were not actually technically asking a lot. Just put some genes in the cells and make them express... nobody could really get that done... we have the same thing with genomics in the pharmaceutical industry right now... [spending] a gigantic fortune on pharmacogenomics... the jury's out on whether or not it was useful...

XT's going to have to come back with a new set of people with some robust technologies and... that's not going to happen now. So I think what you see is the rump end of the old Imutran vision type, maybe dribbling something out... at a low level. You won't be getting lots of people who get transplants. ... it may then come back in a phase two.... phase one is now on a long slope out now. The question is will there be a phase two? And who knows...

In accounts such as this, a number of elements tend to recur. First, the speaker distinguishes between different stages of development. That is, xenotransplantation and gene therapy are described as being

considerably less recent as research fields than embryonic stem cells or pharmacogenomics. Second, ambitious expectations are seen to be rhetorically characteristic of very new or exotic areas of R&D. To this extent, all of these technologies share a common social dynamic where unwise optimism is central. That is, the standard narrative of optimism to obstruction has a social basis. This contrasts with RQL who rejected the application of this standard narrative to stem cells, because stem cells were seen to be 'natural nature' whereas XT entailed 'unnatural nature'. For JJC, the comparability of stem cells and XT lies in their common social dynamic such as the need to hype innovation in order to curry investment.

Discussion – Changing expectations

In what way might this discussion offer insights into the different ways in which innovation actors constitute or engage with the future? We might begin by looking at the implicit models of innovation change and expectations taking shape in some of these accounts. This last respondent was clearly suspicious about the futures being touted for all sorts of health innovations. In this sense then he was dereifying expectation by suggesting that spokespersons for given health innovation areas often over-inflate their early promise and subsequently go on to disappoint. However, whilst dereifying expectation and the future in this way, the explanation works on the basis of a reified notion of innovation change, that is a fairly linear notion of innovation, the serial progression from one stage to the next. This is the standard narrative progression from optimism to obstruction:

Fig 1.

The problem with this model is that it uses high expectations as an index of a technology's early stage of development, and vice versa. That is to say, high or optimistic expectation is discursively correlated with a technology in its infancy: this is something of a circularity. Analytically, it is problematic because our assessments of an innovation's progression along this path are virtually indistinguishable from representations of promise and expectation. So, how is it possible to escape this circularity whereby we base our assessments of the future on the very expectations that we want to critique? Are there other, potentially more fruitful (less circular) ways of thinking about the relationships between forms of expectation and innovation change?

One way of approaching this might be in terms of the relationships between trust in the future and different actors' proximity to the actual scientific work. In other words, let us examine whether expectations vary according to whether someone is practically engaged with the science or, on the other hand, simply familiar with the expectations associated with the science. MacKenzie's²⁴ notion of the certainty trough and also Collins'²⁵ discussion of the 'core-set' are both valuable here (see also, Michael and Birke²⁶). MacKenzie draws a correlation between closeness to the point of knowledge production (innovation, experimentation, testing etc) and (un)certainty. That is, uncertainty will be more acute for those closely involved in the production of knowledge (where experience of the contingencies of knowledge production in the laboratory make one cautious) and 'outsiders/competitors' (who critique knowledge on grounds other than technical grounds, say, moral,

economic or political). By comparison, the users of that knowledge will be somewhat more certain as to its 'truth'.

Fig 2.

In the small fieldwork snapshot that we have just presented, it is possible to identify striking relationships between the proximity to scientific work and uncertainty about the future of different fields. For some of the respondents discussed above, their close proximity to the production of 'facts' about xenotransplantation means that they are more likely to experience uncertainties both about the current state of knowledge and its potential future therapeutic value. This sense of uncertainty, following MacKenzie's observed pattern, is less likely to be the case for the users of that knowledge, except over time when contingencies will become progressively more apparent. Initially however, they may find themselves in the position of subscribing to the promise of xenotransplantation even if that promise is regarded as far from satisfactory by its makers. At the other end of the spectrum are those for whom xenotransplantation raises acute uncertainties, either by representing a clear threat to established techniques or by contravening established moral commitments (animal advocacy say). However, we also need to add a proviso to this account. As we have seen, scientists themselves, when they are wearing their entrepreneurial hat, make strong (certain) claims about the promise of their innovations. On the face of it, this seems to contradict MacKenzie's model. However, if we take a post-structuralist line on the de-centredness of persons, then we can say that scientists assume two roles (or perform two identities): researcher and entrepreneur. The latter is a user of the former's knowledge for the purposes of attracting investment. As such, the entrepreneurial technoscientist can switch between the crest of uncertainty and trough of certainty. There is not a necessary or felt contradiction in this flux.²⁷

However, this does raise questions about accountability, particularly where access to knowledge is unequally distributed. For example, the basic dynamics of the futures market means that expectations are capable of generating enormous near term share value (with which to conduct research or financially reward research staff), but without any necessary requirement for entrepreneurs to fulfil their longer-term promises. This is because the motivations of say financial investors or even patients on the one hand and entrepreneurs on the other are often quite different. Entrepreneurs stand to benefit enormously from immediate share value growth, whilst the burden of longer-term failure usually falls on other kinds of community (investors, patients, public policy makers). Over time, as expectations around early or emerging technologies become more modest and stock values diminish, entrepreneurial communities move into new speculative innovations. The consequence of this tendency within the scientific market investment system is that there are few limiting constraints on the hyperbolic expectations seeded by entrepreneurial innovators. Again, this creates further complexities for those outside the innovation community in being able to realistically understand the future value of new and emerging fields of innovation.

To some extent, the model of the certainty tough offers some interesting insights into different actors' confidence in the future promise of xenotransplantation and their varying distance from knowledge production. But the story is incomplete, largely because the model lacks the ability to account for the

way the promise of xenotransplantation (like that of gene therapy) has altered over time. Most of these accounts describe a xenotransplantation past where uncertainties were less acute than they are today, where the sense of expectation was greater. For all of those who we encouraged to engage in retrospecting prospects, the trough of certainty has contracted, applying to fewer actors. The trough is altogether narrower as we have attempted to portray in Figure 3.

Fig 3.

Many, if not all, the respondents above shared this version of changing expectations (retrospecting prospects of xenotransplantation) and other application areas like gene therapy. However, they fundamentally differed on whether this would apply to newly emerging innovation areas like stem cells (prospecting retrospects). On the one hand, those with very close proximity to primary research in biotechnology were equally cautious of the ambitious promises once associated with xenotransplantation and now associated with stem cells (see particularly JJC) – they were able to generalise across innovations. One might say that this was a discourse of ‘lesson learnt’. On the other hand, actors who might not be so close to newly emerging areas of research and who have been exposed to such uncertainty (especially potential end-users of research - see RQL for example), are less likely to apply the same optimism-disappointment narrative across innovations. These actors could differentiate between old failing innovations and new promising innovations.

Now, such accounts are performative: they serve to enable some technoscientific worlds, and disable others. As such it is important to situate them in their own temporal context. In other words, we should see these statements as both playing a part in prospectively shaping current initiatives and innovations, and responding to the retrospective pattern of initiatives and innovations. In particular, how uncertainty is articulated at once reflects and mediates the way various activities and relations (such as research agendas, regulatory frameworks, funding structures, lay constituency interest and so on) are patterned or networked (c.f. Latour²⁸). This patterning will reflect differences in the degrees to which innovation areas are more or less established, embedded, and routinised. So, on the one hand, new technologies emerge in the context of mundane and unremarkable networks of established actors (regulatory, economic, scientific, public). On the other hand, they must de-stabilise these networks in order to establish their own amenable and fertile associations. Statements about the certainty/uncertainty of technological innovations such as XT, stem cells, pharamacogenomics are deeply implicated in describing the possibility and speed of such network-reconfiguring and building.

JCC’s ‘lesson learnt’ discourse clearly implies extreme caution and grand scepticism as to whether the claimed promise of new innovations will be fulfilled. Yet this very statement serves to waylay that promise: it is part of the process by which a network resists the attempts by those who promote such innovations to establish associations with other actors, and thus to make inroads into particular networks, or build their own. In other words, such statements are not separate from a network nor are they part of some disengaged discourse that overviews the network. Rather, they are a constitutive part of what a network is (c.f. Law²⁹). Similarly, the differentiations entailed in RQL’s prospected retrospects serve as an attempt to establish the viability of a stem cell network. In both cases, such prospected retropsects are instrumental in (re)constituting present and future networks.

Now, the discussion above has emphasised that the performative aspects of prospected retrospects, the goals of different actors (e.g. RQL and JCC), are crucial. Nevertheless, we need to ask if there are any more general patterns or dynamics in the ways that emergent technologies are assessed as either full of undiluted promise or headed for oblivion. Less overtly, and more specifically, we wish to explore whether it is possible to map relations between the relative (un)certainty about an innovation's future and the state of relationships which such innovations are likely to at once draw upon and enter. Figure 4 is an attempt at representing some of these patterns and dynamics.

Networked relationships and activities clearly vary in the degree to which they are either already embedded and routinised or, on the other hand, whether they are newly emerging and highly unstable. In addition to distinguishing between differing degrees of stabilisation, we might also distinguish between 'what is being done' (activities) and 'who is doing it' (networks). In the model we propose, activities are represented by the horizontal axis and networks are represented on the vertical axis.

The distinction between networks and activities is a conceptual division and not an empirical one. It is entirely impossible to have a network that does not involve activities, nor is it possible to have activities without networks. Distinguishing between networks and activities is important however because they are quite different dimensions of innovation. It is for instance, possible for established networks to be presented with quite new and emerging ways of doing things, but without necessarily entailing radical change within the network. Of course, this must not be taken to suggest that change will not occur, simply that it will vary in how sweeping it is. On the other hand, relatively established technologies from one sector can completely reshape a network and force the emergence of entirely new relationships, institutionally and professionally. Again, it is not our suggestion that a technology will not be reshaped as it enters a new network, simply that it is possible for a network to undergo more radical change than that seen in the newly introduced activity.

Fig 4.

Let us explicate Figure 4 in a little more detail. Returning to MacKenzie's uncertainty trough, those who experience least uncertainty (especially end users) will find themselves tending towards the lower left hand corner of the model where networks and activities are reasonably established. Prospective-future users however will on occasion be encouraged to entertain the possibility of considerable change and its uncertainties (top right). For the most part, acute uncertainty would be the province of those directly involved in primary research, again tending towards the upper right hand corner. However, as we have remarked above, whilst these uncertainties may be expressed in private, they are often accompanied by forceful public expressions of promise and potential. The performance of expectation and uncertainty will then vary according to audience. In this area of the model, we will also find those constituencies who might be alienated from the network or those committed to an alternative technology who risk being displaced.

Many, though not all, innovative health technologies will occupy the upper right hand corner of this diagram: emerging activities which are relatively novel or exotic and which usually require quite new forms of organisational and institutional network: XT, stem cells, pharmacogenomics, etc. Conventional approaches will find themselves occupying the opposite area of the diagram.

More importantly, the kinds of discourse around future and promise will likewise vary according to the positioning of actors, discourses which might galvanise relationships, encourage new interest or convince outsiders that there is promise in a particular research venture. The more acute the uncertainties, the greater the need to marshal the emerging activities of an unstable network, often by engaging in discourse around the revolutionary-breakthrough-potential of the promise. Our argument then, is that radical discourses about the future are indicative of the emergence of networks (new relationships) and activities (new activities). On the other hand, where networks and activities are established, we might often find huge investment in preserving existing networks, insulating the field from threat through planning, administration and bureaucracy as a form of future-oriented activity. It might also be the case that, for potential users of an innovation, we would see here a diminished capability to be cautious or uncertain about expectations emanating from emerging networks and activities. This might be understood as future 'naivety', a consequence of distance from the uncertainties of knowledge production.

Finally we must stress that xenotransplantation and all the application areas mentioned so far are in a complex state of flux and re-alignment. Some features of the technology are likely to occupy several dimensions of this chart at the same time. They will be simultaneously both novel-emergent and mundane-established. For example, XT's therapeutic promise may remain firmly fixed in the top right hand corner of the model, entrenched in uncertainty and occasionally given to breakthrough announcements of new progress. But other aspects of the technology have made their way into niche applications in basic science research (in immunology, transgenics,) without necessarily involving radical change in the relationships between actors. Here, it is possible to observe new activities being taken up by established networks, being drawn down into the bottom right hand corner of the diagram. This is why it has been important to analytically distinguish between networks and activities, since both may differ in whether they are established or new. Gene therapy, has similar innovation properties, simultaneously pushed out of the therapeutic frame as a wide-ranging remedial activity, whilst niche areas are pulled down into established networks within the research community (bottom right).

The purpose of this analysis is to offer a basis for modelling the situatedness of future-oriented discourse and the complexity of innovators' roles expressed in these overlapping accounts of established and emerging, networks and activities, certainties and uncertainties. We have tried to sketch a preparatory and heuristic framework for analytically getting to grips with the complexity of performative statements (especially prospected retrospects), and their possible implications for the network in which they are embedded. Needless to say, our own model, as a minor social scientific innovation, is no less subject to the very processes we describe. As ever, it remains to be seen whether its prospects will merit retrospection.

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