Evolving Collaborations:
A self-referential case-study of a social/ natural sciences collaborative project

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In this paper we aim to study the workings of a cross-disciplinary project in practice, and to relate our approach to other ways of achieving similar goals. By reference to our experience of a project to involve volunteer research subjects more actively in research on developing a new health technology, we explore the dynamics and evolution of the collaborative relationship between the medical physicists and social scientists as the project matured over a number of years. We discuss the tensions within the relationship and the capacity of a collaborative mode of working to sustain or constrain agendas relevant to science and society issues. We conclude by suggesting that we may be evolving towards a new mode of collaboration, similar to that starting to be institutionalised in some other natural science fields (nanotechnology, for example) and stimulated by shared aspirations towards embedding societal concerns in science.

Keywords: interdisciplinary collaboration, technology development, societal values, interventions

This paper presents the story of an interdisciplinary collaboration, which is used to explore the practice of collaboration in contemporary social and science policy contexts, how it evolves, and what capacity this mode of working might have to sustain or constrain different kinds of interventionist agendas relevant to science and society issues. The story concerns a collaboration informally arranged between individual scientists, initiated by the authors in 1999 to test the feasibility and usefulness of involving volunteer research subjects (hereafter normally referred to as 'volunteers')

more actively in research on a new health technology. At that time a team of physicists working on biomedical optics were just about to embark on an initial clinical evaluation of a new imaging system using optical wavelengths (rather than x-rays or ultrasound) that had potential for the diagnosis of breast cancer. The first author (from an STS department) met with the physics team leader (co-author) to suggest that there might be mutual benefits if she could interview his volunteers about their experience, and systematically feed back to the research team information from

the volunteers' accounts which could be useful in further developing the prototype instrument and the test protocol. This would further the social scientists' agenda of studying the potential of this untried mode of 'user' involvement for influencing research trajectories and open up a space for discussion of what the experience of taking part in research means to the volunteers. It was agreed that these topics were also relevant to the physicists and the practice of breast imaging. We subsequently worked out the details of the collaboration as we went along.

The proposal was from the outset framed as a collaboration, based on a tacit shared understanding of what collaboration meant. As the study progressed, however, questions as to whether this was 'collaboration' or would be better described as sociological fieldwork began to emerge. During the first phase of the project the dominant focus was the analysis and feedback of the reactions and priorities of volunteers, and discussion of their implications for the imaging project. This conformed to our vaguely formulated notions of collaboration. In the second phase, with longer experience and following improvements to the technology and protocol (to which volunteer feedback had contributed in some measure), volunteer reactions rapidly became more or less predictable, as did the extent to which they could, or would, expect to influence the development of the imaging methodology. Emphasis then shifted to researcher-subject relationships in which the researchers became as much a subject of observation as the volunteer participants. The scenario began to resemble conventional sociological fieldwork, with the physicists being the fieldwork site, providing access to

volunteer human subjects and to their own interactions with the volunteers. This was not part of our tacit model of collaboration. Yet the sense of mutual input and mutual benefit (the key components of most definitions of collaboration) remained, and we found that notions of collaboration could stretch to accommodate changing circumstances and reconfiguration of roles. We also became aware of analogies between our evolving relationship and the kind of collaborative engagement between natural and social scientists already evident in some fields of science having particular interest or implications for non-scientific publics (e.g., nanotechnology). This suggested that we were still collaborating but in a changed mode.

In this paper we trace how a collaboration is negotiated and performed through the stages of initiation, 'growing pains', maturity, closure, and afterlife, giving attention to: the evolving roles and identities of the collaborative partners; tensions arising; and the influence of institutional and funding contexts. This forms the basis for a discussion of how far this model of collaboration was problematic or productive in relation to the goals of fostering volunteer participation and intervening in research practice to make a space for incorporating patient/volunteer needs. On the basis of our experience we consider how far such a mode of working can sustain an interventionist agenda, how it might shape the intervention, and possibilities for convergence with other, still experimental, modes of natural/ social scientist cooperation emerging in other fields.

Our detailed study of the workings of one collaboration aimed at addressing socially-relevant issues has potentially

more than parochial interest given current concerns about science and society relationships and the proliferation of initiatives from funding bodies, interest groups, and scientific group leaders to stimulate various modes of joint working between social and natural scientists with the aim of embedding a greater social consciousness into the practice of science. The form of many such initiatives lays emphasis on the robustness of the relationships between the scientists as much, if not more, than the outcomes in terms of public engagement. Our study provides one example of how such dual engagement may work out in practice.

The paper is written from the viewpoint of the authors, who were engaged with the project throughout. Others have been substantially involved for shorter periods, but while we include their views where available in our narrative we do not claim to represent their experience and understanding of the collaboration, which may well differ in each case. Nor do we deal directly here with the relationship between either team of researchers and the volunteers, though these too were to some extent collaborative.

Situating the work: science policy and prior literature

Science policy

One of the most significant shifts in science policy in the last two decades has been the new-found prominence of science and society relations. Greater respect for lay understanding and views on matters once the exclusive province of the expert scientist is now an accepted premise of UK science policy (House of Lords, 2000; Wilsdon et al., 2005), and under the rubric 'patient empowerment' widely advocated as essential to an enlightened doctor-patient relationship (General Medical Council, 2006; Smith, 1999). Similar policies prevail elsewhere in Europe and the US, manifested initially through the ELSI (US) and ELSA (EU) programmes and more recently through a more ambitious understanding of public engagement, especially related to the nanotechnology field (see for example Fisher and Mahajan, 2006a; Macnaghten et al., 2005; Rip, 2002; Wilsdon and Willis, 2004). These developments have provided fresh opportunities for social/natural science 'collaborations' and for social scientists to become involved in the development and implementation of research and policy agendas. They have also further stimulated the ongoing debate among academics about the practical and conceptual challenges such engagement may raise for social scientists, and particularly for STS scholars (Lynch and Cole, 2005; Markussen and Olesen, 2007; Webster, 2007; Woodhouse et al., 2002).

Collaboration, and interdisciplinary collaboration in particular, has long been supported by science-led funding bodies (see for example Kohler, 1976; MRC, 1971). Its debut as a front-line government policy for science (in the 1970s-80s) preceded the science/society concerns, coming as governments in most advanced nations rethought their policies for science in response to changing social, economic and political conditions (Blume, 1982; Rip, 1997). The implications of social change for knowledge production were theorised by Gibbons et al (1994) in terms of a shift from Mode 1 (discipline-based) to Mode 2 (multidisciplinary, multi-actor). Though the characterisation of Mode 2 as a new phenomenon may be contested, especially by engineers and biomedical scientists who have long worked in 'the context of application', the concept forcefully captures the heightened

importance of cross-disciplinary, socially accountable and multiply collaborative research under the emerging policy regimes. The concepts have been further refined in later writings (Nowotny et al., 2001; Nowotny 2003) to emphasise the need for 'socially robust' science, which integrates societal values, and which, it is claimed, can also result in better scientific and technical solutions.

The impetus for Government policies in support of collaboration remains their faith in science as a key driver of national economies. Thus there are mechanisms in place to boost collaboration between academics, aiming in part to make best use of expensive resources, but also to reap the intellectual and economic benefits expected from cross-disciplinary working. Government policies of giving funding priority to collaborative work (as in the EU 7th Framework Programme [EU, 2007; NIH, 2006]), including promotion of collaboration with industry and other users (Etzkowitz and Leydesdorff, 2000; DoH, 2005); Slaughter and Leslie, 1997), have stimulated widespread interest in collaboration as a funding opportunity and a means of giving a further competitive edge to research proposals.

Such policies helped set the stage for our own collaborative project. In September 1999, ESRC and MRC jointly launched a programme on Innovative Health Technologies focusing on the question: 'How will people and society be affected by, and in turn affect, innovative health technologies?' which was referred to at our initial meeting as legitimating a cross-disciplinary collaborative approach to extend the work into societal aspects. Similarly notions of social studies of science researchers' facilitating a more active role for the volunteer 'users' drew strength from its links to a burgeoning policy agenda.

Literature on scientific collaboration

A further significant contextual factor that led to our framing our joint work as collaboration was the well-established position of collaboration as part of the work practice of scientists of all kinds, and the extensive scholarly literature reinforcing and analysing this. The literature confirms the flexibility of the concept and emphasises the pragmatic motives for entering and sustaining collaborations, as well as providing some tools for analysis of collaborative dynamics and the possibilities of migration between modes of working.

Katz and Martin (1997: 16) observed that collaboration was difficult to define, partly because: "the notion of research 'collaboration' is largely a matter of social convention among scientists". Our experience suggests however that a shared understanding of the conventions involved holds good across disciplinary boundaries, thus making it an attractive formula to use, initially at least. Though collaboration may resist definition the empirical literature identifies key characteristics and dynamics associated with collaboration sufficient to create a 'family resemblance' among its many individual manifestations. One key characteristic is that collaboration takes place where the scientists see something to gain – typically access to special competence or resources, but also including social benefits from networking and sharing of scientific and technical human capital (Bozeman and Corley, 2004; Lee and Bozeman, 2005; Melin, 2000; Thorsteindottir, 2000). Another, highly valued, characteristic is enhancing the quality of scientific/professional life, by intellectual stimulation and sharing excitement and enjoyment with others (Beaver and Rosen, 1978; Beaver, 2001; Laudel, 2001). A further feature often

taken to be a marker of collaboration both at the institutional and individual level (Lawrence et al., 2002; Katz and Martin, 1997; Beaver, 2001) is autonomy of collaborative partners. This has been absorbed into funding policy for collaboration, which appears always to assume alliances negotiated between peers. We note that such a footing is in contrast with certain other bases (such as a third party commissions) on which social scientists gain licence to intervene in work practices.

The literature also discusses the differing dynamics of working encompassed under the general notion of collaboration, particularly interdisciplinary collaboration (Klein et al., 2001; Nowotny, 2003). The term *multidisciplinary* is used for the least integrated mode of working, where 'each discipline works in a self-contained manner' (Bruce et al., 2004, p 459) or where 'several research programs are only contributing to a given theme from a clearly disciplinary perspective' (Balsiger, 2004: 412). *Interdisciplinary* involves a 'mixing of disciplines', contrasted with *transdisciplinary* working which is a 'fusion of disciplines' (Lawrence and Despres, 2004: 400). According to these authors most collaborative work falls into the categories of multidisciplinary and interdisciplinary. These bear some resemblance to what Hagstrom (1965: 112-121) termed collaboration with or without a division of labour and the distinction made in later texts based on the degree of mutual stimulation and creative or potentially creative intellectual exchange between the disciplines (Laudel, 2001). As with most other generalisations about collaboration however, exceptions abound and categories blur into one another (Katz and Martin, 1997).

A richer account of the dynamics of collaborative working, in which we recognise elements of our own practice, is given by Galison ([1987] 1999: 137) who observed dealings between different strands within the single discipline of physics: "…the many traditions coordinate with one another without homogenization. Different finite traditions … … meet – even transform one another – but for all that they do not lose their separate identities and practices." Galison ([1987] (1999: 138) treats of traditions as subcultures of the larger culture of physics having enough in common at their boundaries to establish a 'trading zone', where 'the trading partners can hammer out a *local* coordination despite vast *global* differences'. This is not dissimilar to Lynch's notion (2004: 9) of 'local interactional spaces' to accommodate interests and expertise as widely disparate as STS, business, and the law. The trading zone analogy – with its acceptance that the objects traded may have different meanings for the different parties (Galison, 1999: 146) – captures both the vigour and the limitations of much interdisciplinary collaboration. It also carries the implication of a topography of collaborative interactions (a topography that will vary according to each partners' angle of vision). Within the region of intensive interactions there may be instances of convergence or exchange of roles and constructive exposure to different viewpoints, styles, and standards of evaluation. Outside the region of joint interest exchanges will be more formal, more circumspect, or non-existent. Thus the multi-disciplinary and inter-disciplinary modes can co-exist within the same collaboration. We shall go on to discuss later how these characteristics and dynamics were reflected and enacted in our own collaboration.

The key features of the attractiveness of collaboration as a basis for our working relationship were thus its familiarity and

flexibility. Despite different disciplinary backgrounds we could assume a shared understanding of the 'rules of engagement' and space for different modes of interaction.

Research on 'interventionist' or 'engaged' STS

Part of the motivation for our project came from a shared interest in what could be contributed by greater involvement of patients and public (and especially the rather neglected category of volunteer research subjects) in research and decision-making, and in testing how or if this would work in practice for both the researched and the researchers. Thus, while sympathetic to the principle of involvement, we retained a level of scepticism about whether research volunteers such as we would study, transients whose personal health care was not at issue, would accept greater involvement and be willing to engage with analysis of the technology and of their experience. The acceptability and/or relevance of the volunteers' views (and of the intervention in their work practices) to the researchers and the research were also open questions. This distances us in some ways from the debates in the STS literature on engaged or interventionist research, but not from the issues and problems its analyses point up.

Increasing interest in engaged or interventionist research in STS has been marked by various special issues of journals, discussion forums, books and workshops exploring both conceptual and practical issues[2]. A particular issue is the challenge it poses for STS scholars in finding the right balance between "the risk of irrelevance and disengagement on the one side and cooptation and loss of prestige and resources on the other" (Hackett et al., 2007: 1). Lynch and Cole

(2005) explore some of the uncomfortable compromises STS researchers may be forced into when taking an active role within a system (in this case in a court of law) which has its own firmly entrenched norms and practices. Jensen (2007) develops this theme in the context of health care practices, emphasising the performativity and situatedness of the researcher, and analysing how terms of engagement between actors are constrained by existing institutional environments which may structure the research itself and its outputs. This invites consideration of how our collaborative model, though different from Jensen's examples, might operate in similar ways. The debate between Webster, Nowotny and Wynne in recent issues of SHTV (2007) also highlights issues of the potential for attenuation of radical messages in the policy domain.

Thus engagement with other organisations and cultures presents problems of legitimation and focus, which may hinder the interventionist intention of STS or other researchers or compromise the integrity (or at least the scope) of the research. In the narrative and discussion below we shall discuss how far these tensions were present in our work and how far our casting of our project as a jointly performed experiment might distinguish it (for good or ill) from other kinds of engaged STS.

Case study: Inside story

The collaborative project

Initial basis. The nub of the association between the social science researchers (SSRs) and the medical physics researchers (MPRs) was the proposal to extend the existing protocol for running clinical tests of the prototype imaging instrument. We added to the protocol observation

of scan sessions and interviews with the patients and healthy women who came as volunteer human subjects (hereafter referred to as 'volunteers') to be carried out by the SSRs. Regular feedback from SSRs would provide the MPRs with additional data on the performance of their instrument and their procedures when dealing with 'real people' rather than the plastic simulations they had been using up to this point. Thus the proposal was designed as a contribution to and integral part of the imaging project, and was particularly appealing to the MPRs at this time as they were conscious of their lack of hands-on experience in clinical research and the additional responsibility and potential challenges of 'research materials that "talk back"' (Epstein, 2007: 185). It was understood that the SSRs' interests extended to studying more generally the experience of volunteers in medical research and, in particular, their potential to contribute more actively to research outcomes. This might be an early enough stage of the project for the volunteers, as articulate quasi-users, to influence the development of the technology at its laboratory prototype stage, rather than later when it was near-market and less malleable to change.

In relation to subsequent discussion of the evolution and resilience of the collaboration it is relevant to note that we were able to negotiate our initial 'terms of engagement' as independent scientists, through informal processes described in more detail later, without imposed external requirements. The SSRs would make a tangible contribution of additional data and there would be discussion and agreement on its use, as expected in collaboration. The intervention in research practices was thus written into the research protocol from the start. The agenda of 'giving a voice to volunteers' was accepted, on the mutual understanding that the benefits of so doing, and doing it this way, would be assessed on the basis of a variety of outcomes and possibly a variety of viewpoints. Both SSRs and MPRs were open-minded as to whether the exercise would justify itself in this context. This relative absence of commitment to prior positions fitted the notion of collaboration and avoided some of the tensions inherent in interventions that threaten entrenched positions.

Project description. The goals of the project may be summarised as:

> By means of participant-observation of volunteers undergoing experimental breast scans, and semi-structured interviews with them post-scan to assemble data on
>
> - the acceptability/user-friendliness of the instrumentation and processes
> - the experience of being a research volunteer
> - the willingness and capacity of volunteers and MPRs to engage in this way
> - effects of feedback and discussion of data with MPRs on technological development and research outcomes
> - effects on volunteers (eg on well-being)

We omit details of the methodology and outcomes of the breast imaging project and the volunteer-centred extension of it as not necessary for the present paper, but need to say something about the volunteers and how the physical configuration of the instrument changed between phases 1 and 2 of the project, to clarify the account of the collaborative dynamics and the substance of volunteer feedback.

The volunteers were mainly women attending a local breast clinic, with diagnosed or suspected breast cancer or a variety of benign conditions. Sixty-five volunteers were interviewed: ages ranged from early twenties to over 70, and they spanned a range of social backgrounds. During the first phase of the imaging project measurements were performed using a simple interface consisting of a plastic ring to which the optical sources and detectors were attached, mounted on a vertical frame (Yates et al., 2005). The volunteer was required to lean forwards against the frame, with the left or right breast placed within the ring. No compression of the breast was involved. However, achieving reliable data required optimum positioning of the breast within the ring, and thus the imaging process was dependent upon eliciting a significant degree of cooperation from the volunteer.

To improve reliability, the second phase of the project employed an alternative scanning interface, with the volunteer lying face downwards on a bed with her breast placed in a hemispherical cup inset into the bed (Enfield et al., 2007). The space between the breast and the cup is filled with a milk-like scattering fluid, which maintains all-round contact. This design enables the volunteer to adopt a more relaxed posture during the scan, and indeed some have reported coming close to falling asleep.

Negotiating the programme of research

The interval between the date of the initial meeting to set up the collaboration in principle and the first scan of a volunteer (May 2001) was rather more than a year and a half. The experience of the volunteers constituted a key focus of mutual interest during this period as the MPRs started to think through all aspects of their process with the patient in mind:

> I think what has changed in the last 6 months is … … … is how in practice to implement our methods. … …We have new ideas – 'why don't we try it like this' we are saying. I – we are thinking more along the lines of patients rather than, if you like, a piece of plastic. (MPR1, meeting of 04/08/00)

The MPRs specific goals also became clearer as generalised concerns about clinical acceptability coalesced into more specific concerns about how comfortable the volunteer would find the scan and how long the process would take. Although the length of time needed to perform the scan was only about 10 minutes, initially there were major concerns about the reliability of the instrument, which in laboratory tests would occasionally halt unexpectedly during a scan. Volunteer feedback obtained through the SSRs would benefit the MPRs by helping them gauge the seriousness of these problems and how best to manage them. Thus the grounds for the mutual benefit basis of the collaboration were confirmed, and thereby its credentials as a collaboration.

One arena for the discussion and negotiation of the programme of research was the exchange of drafts of funding applications and ethical committee (institutional review board) approval. The MPRs already had funding for initial tests of the instrument on patients and healthy volunteers, but funding for the study of volunteers' role still needed to be secured. The exchanges assured that the proposal fitted the expectations and needs of both MPRs and SSRs and the lead physicist was named as a co-applicant on the funding application.

Contact by email and periodic meetings was maintained over this period, so that the protracted timescale paid dividends in terms of our becoming comfortable with each other. For example, the exact

timing of the interview (immediately after the scan) and whether the SSR would be welcome to be present for the whole session (including consent process and laboratory scan) was left fluid until shortly before the first volunteer was due. By this time, through a process of mutual familiarisation and learning (see the 'artful contamination' of Zuiderent-Jerak and Jensen (2007)), the SSRs were sufficiently integrated with the work that there was no need for negotiation; we all felt that having them present throughout was not only logistically simpler, but might also offer advantages.

The SSRs learnt a lot about the tempo and dynamics of cutting-edge engineering research projects, as various modifications to the imaging system (and some practical questions about manpower) caused the expected date for scanning the first volunteer to be shifted further into the future. Meanwhile further applications for funding the social science arm of the project were discussed and drafted. Through their part in this, the MPRs became fully conversant with sociological framings of questions of volunteer experience and technology and society.

First phase

The scan of the first healthy volunteer in May 2001 and the meeting that took place after three scans had been done (February 2002) were significant events in consolidating the collaboration. Discussion at the meeting confirmed the MPR's perceptions of the role of the SSRs as contributors of useful data. The observations and discussion were welcomed as a very helpful and more systematic supplement to the MPR's customary approach of keeping only mental notes of comments made by volunteers. Additionally they identified a less tangible contribution, coming from the discussions with SSRs. Though they had long been conscious of the issues about functionality and acceptability to patients, they said they felt the collaboration had heightened this awareness with positive effects—a result that assumed greater significance when we entered the second phase of the project. At the time, the issue of functionality was dominant and the MPRs were already addressing this by empirical testing of alternative designs, based principally on what they had learned at scan sessions, not only from patients' difficulty in positioning themselves, but also, perhaps principally, from the disappointing performance of the original design (of the first three scans performed, only one had yielded usable data).

Later discussions however made it clear that they (or to be precise, the team leader) considered patient/volunteer comfort and good data acquisition to be intimately intertwined, partly because of the effect on the researcher: "He thought better volunteer compliance gave better quality. If the volunteers were relaxed, he felt relaxed. Researchers were less likely to make mistakes: they did not feel obliged to hurry." (Meeting of 14/02/03) The MPRs also felt that if the volunteer were more relaxed, they were more willing to ask her to make further adjustments to her position to facilitate better quality data. This drawing together of technical and human performance conferred some added legitimacy to the suite of comparatively trivial improvements directly triggered by volunteers' comments (such as adding more comfortable padding, offering background music, etc.) and opened up a wider interpretation of how engagement with volunteers might influence research outcomes. It indicated another way that the SSRs' collaborative role (or 'intervention') might be making a difference.

Progress and products of the first phase. In 2003 the first publication on the work with volunteers appeared, under joint STS/Medical Physics authorship, and published in a physics journal (Morris et al. 2003). This had grown out of a presentation at a major European optics conference, given by NM, after coaching from the MPRs to get the abstract into a form acceptable to the programme committee. This enabled us to share our (interim) findings with the optics community, with potential of possibly influencing research practice of other teams engaged in clinical testing, and confirming the work's status as a matter of *joint* interest, jointly produced. A further significant product was a joint funding proposal which incorporated MPR input on themes to investigate, (e.g., researcher anxiety) and was successful in securing funds for a second phase collaborative project.

We also gave jointly authored presentations at three STS meetings. However, after discussion subsequent publications based on these did not include the physicists as authors. In parallel fashion, the SSRs do not feature as authors on papers produced by the MPRs which describe either the breast images produced from the volunteer studies or the design of the instrument and the imaging methodology. These may be thought of as tracing the borders of our 'trading zone' or of *multi-* and *inter*-disciplinary collaboration (see below) and helped assure that individual agendas were not constrained to matters of consensus.

This first phase of collaboration was non-problematic insofar as it matched well with our expectations and the characterisation of collaboration in the literature, i.e., that both partners had something to gain where the goals of the collaborative project were directly related to personal research agendas; both had skills and resources to contribute; and the marriage of these resources was essential to getting the work done. We had generated joint products in demonstration of the benefits accruing, and separate products to pursue our individual professional goals.

In terms of the analyses in the literature of the dynamics of collaboration, our mode of working had elements of the multi-disciplinary: We had clearly demarcated roles, and for much of our time 'work[ed] in a self-contained manner' (Bruce et al., 2004: 459). For the MPRs, the SSRs were just one among a number of groups with which they collaborated. For example there was a long-standing collaboration with a group of theoretical physicists/computer scientists who develop software for the 3D reconstruction of images; there were more recent collaborations with clinicians, who were relied on to refer patients and who advised on clinical need and clinical acceptability from the surgeon's perspective. Each of these and other collaborators occupied a particular space—only occasionally overlapping—in the territory of the breast imaging programme. However, while disciplinary identity remained distinct, and the contributions expected from all parties were well defined, the interactions between the disparate disciplines (in our case at least) at the points of intersection (our 'trading zone') involved exchange of ideas, mutual learning about each others' culture, and mutual influence. Such interaction would qualify as 'inter-disciplinary collaboration', which is valued because of the opportunity it provides for creative stimulation over and above the value of provision of a service or expertise necessary for the project (Laudel, 2001). It also allows the possibility of convergence of roles and transfer of expertise.

Second phase

By the end of the first phase of the project the MPRs had decided on the major redesign of the scanning interface referred to earlier – largely on technical grounds though with some influence from volunteer input. In the second phase collaboration larger numbers of patients—with, on the whole, more serious disease—would be tested using the new scanning interface. Though following the same protocol as the first, the second phase developed a rather different dynamic. It produced, even within the first four months, a wealth of interesting data. We rapidly reached the stage where the cumulative data from the two phases of the qualitative study amounted to a considerable body of evidence that would not easily be overturned by new findings. Progression in the future was therefore likely to be incremental, to confirm or modulate existing findings, rather than to involve immediate or radical actions. Productivity was observed to decline according to the familiar law of diminishing returns: the more patients we interviewed, the smaller the probability of learning something new. In social science terms, we had reached saturation in terms of volunteer input to technological and process development (though not in respect of the volunteer experience as a whole). This phenomenon was rather more taken for granted by the MPRs than the SSRs. Another factor seeming to diminish the SSRs role was that the MPRs' capacity to relate productively to volunteers was enhanced by learning from the first phase and the recruitment, in the light of this experience, of a post-doctoral scientist with prior experience of handling patients for the second phase.

Furthermore, the introduction of the new scanning interface significantly changed the character of the research encounter. The physical challenges of taking part in the experiment (never very great according to the volunteers) were significantly reduced by the new design of interface, as was the need for careful positioning (requiring active cooperation from the volunteer) to assure good quality readings from the scan. Good images were being obtained in virtually all cases, and volunteers, despite a certain level of tension and minor discomfort, mostly described the experience as 'relaxing'. The focus of the collaboration shifted from questions of physical and mental comfort and design (though volunteers continued routinely to be drawn into talking about these) to questions of the researcher-subject relationship and management of the half-hidden anxieties on both sides.

For the SSRs this raised the issue of how valuable feedback on topics of this sort was to the MPRs (since little in the way of quantifiable action could be expected as a result) and how far the SSRs were still contributing as collaborators to the imaging project. Were they in danger of becoming parasitic, in the sense that they were feeding off the MPRs to produce analyses that would be only of STS, rather than joint, interest? And would it not be unethical, having been invited in as collaborators, to use that access merely to conduct sociological fieldwork in which the MPRs as much as the volunteers were research subjects? The conventions of collaboration appeared to be in conflict with continued pursuit of the SSRs goals. We addressed this in discussion.

Exploring differences. Questions about the status of the second phase collaboration stemmed in part from differing interpretations of what the first phase had achieved. The SSRs had set out to show how far, if at all, the enhanced participation of volunteers had influenced research

outcomes, as measured by changes in equipment design or in the direction of the research. SSRs were inclined to judge volunteer input into the major redesign of the scanning interface as insignificant, which implied that the collaboration, though providing important supporting evidence for decisions inspired primarily by technical considerations, was not in fact essential for getting the work done (a factor often taken as defining of a 'good' collaboration). An interview with one of the MPRs revealed a similar view:

> I would say that's been designed entirely on the basis of the science and our desire to get better data. I think it will also be more comfortable for the patients, but if you like, that was secondary to getting the quality of the data. (Interview with MPR2 14/07/03)

The physics team leader however had a different interpretation:

> I think [the Progress Report] understates the influence your limited study has had on our work, in two respects. First, I believe it has given us a greater awareness of the needs and concerns of the volunteers/patients. At least, if I were starting another imaging study (involving adults) from scratch, I think I would need to ensure that some mechanism for obtaining volunteers' feedback was in place. Second, the development of our second system has certainly been influenced by volunteer/patient comments regarding comfort, safety, etc. (Email of 03/11/04)

This introduces a different measure for the mediated volunteer input – its effects on the MPRs' awareness. It shifts the focus away from the physical comfort of the volunteer, with its functional

concentration on limits of physical tolerance or willingness to cooperate, towards a more social understanding of the clinical research process and possibilities for engagement with volunteer subjects. Thus work on the first phase project had (in this articulation) brought the MPRs' goals closer to those of the SSRs concerning better understanding of the dynamics of the research situation.

We explored further what these developments meant for the future of the collaboration in routine interviews with MPRs and a team meeting in January 2006. The view reached in discussion was that the relationship was symbiotic: This both rejected the notion that it was parasitic and reflected the feeling that the work had, temporarily at least, reached a steady state, whereas our original notion of collaboration implied a time-limited project of working together to achieve a specific target or set of answers. The feedback from interviewing volunteers had reached a plateau, with little emerging that was new or not already well assimilated by the team. Nevertheless, MPRs had modified their interpretation of the SSRs' role to ascribe value to the feedback as what might be described as a monitoring or quality assurance function. One commented:

> It does seem there are only certain areas that people will comment on, but you never know, someone might mention something that you haven't thought about. (interview with MPR3 of 30/11/05)

and MPR2, the most sceptical of any serious volunteer influence, said (translating the SSR role into the language and values of his own scientific culture) that SSRs had contributed 'better evidence' for decisions made (e.g., on modifying the interface) and been able to act as 'a neutral third

party' to elicit views or issues that might have otherwise escaped the team. This insider-outsider role had previously been identified in different words by the team leader, in commenting that the feedback of information from volunteers

> provides a safety valve in a way, that whatever we do, whatever we have done, if there is a problem with regard to the patients, I know I'm going to hear about it and so that enables us to adapt things to become a bit more fluid in our general approach. (interview of 11/07/03)

Participant-observation at the scan session operated in a similar way

> it's that safety valve thing again. That Norma sees what's going on . … it's a comfort to us to know there's someone there who is able to make that kind of diagnosis, if you will, … …. Particularly as we have other jobs to do and although we obviously are aware there's a patient there and doing our best … … 100% of our concentration is not devoted to the patient. (interview of 11/07/03)

This is a rather different role from that at the start of the first phase. Though limited as a view of the SSRs' function, it was a role the SSRs thought they could incorporate with good grace, in the same way as the MPRs had accepted the role of research subjects. The revised emphasis constructs the SSRs as both 'insiders' and 'outsiders' (see Mesman, 2007: 290-291)—collaborators in fact— and was a position the SSRs themselves had cultivated in their dealings with volunteers. It may be thought of as integrating social science more closely into the project by identifying for the SSRs (and the non-physics, non-mathematics topics they represent) a

long-term role in the project team. This conceptualises the SSR role as fulfilling a specialist function in the management of the experiment, analogous in a way to the function of the technically skilled team member who was 'driving' the highly complex optical imaging instrument to ensure it was functioning optimally and acquiring the best possible data. The SSRs' specialist role consisted in helping establish principles of managing the volunteers and overseeing the working of the system to ensure the volunteers were similarly performing to their full potential and not suffering physical or emotional discomfort. This is not to denigrate the volunteers, or to treat them as instruments or 'lab rats', or deny them opportunities for other sorts of inputs; it is rather recognition by all the researchers of the special claims and special needs when fellow human beings are integrated into an experiment, and the responsibility to design and implement an experimental system that will respond adequately to subtle signals and human sensitivities. Though the role accorded to the SSRs is mundane and reflects only one part of their agenda, the incorporation of these considerations into research practice is a step towards greater 'visibility' for volunteers.

The SSRs' nervousness about whether they were', as time went on, simply exploiting the MPRs seemed to have been misplaced. Research was still possible within a collaborative rather than ethnographic framework, but did require an adjustment of the SSRs' ideas in several ways. First was recognition of the new kind of utility they had been afforded as quasi members of the team: this was not seen as a problem since they retained their collaborative freedom to develop their own research agenda in parallel. Second was rejection of the facile notion that the MPRs' interest was limited

to 'fixing a problem' rather than widening understanding to the possible benefit in the longer term development of their instrumentation and protocols. Third was recognition that collaboration could evolve and take different forms over time, and thus endure across changes in work patterns and outputs. A resolution along these lines was preferred to the notion of shifting to an access agreement since the SSRs' research aims had always been as much to engage with the researchers as with the volunteers, with the idea of jointly testing rather than unilaterally promoting the 'cause' of participation.

Though our re-evaluation reaffirms a collaborative basis for the present, it seems likely that the 'quality control' role could in due course be absorbed structurally into the physics team, along the lines of the development of their competence and staffing structure that has already taken place. Our 9-year association also provides a platform for further periodic collaboration as new issues or problems present. Meanwhile we have noticed that the mode of working we have settled into seems to have counterparts elsewhere.

New modes of collaboration

Societal values. Our current way of working together has some features in common with modes of social/natural science collaborations developing in several other fields (including nanotechnology, genomics, environmental studies), which like human subjects research are of high public sensitivity and interest. May this signal the emergence of new forms of collaboration particularly suited to today's climate of sensitivity to science and society issues? A common aim is to integrate into the normal practice of research relevant societal values to the benefit of both research outcomes and

research participants/users. In our case the relevant societal values are the needs, interests and opinions of the patient-volunteers, whereas nanoscientists, for example, must engage with a broader public over a wider range of issues and at a stage where their research is much more open-ended. Nevertheless, we see methodological and operational convergences in (a), the increased emphasis on early engagement and continuous feedback, and (b), the symbiotic relationship implied by the integration (sometimes as staff members) of social scientists into natural science institutions and projects. Further similarities include:

- focus on natural/social scientist working relations;
- mutual benefits and potential for creative interactions;
- ambiguous status of natural scientists as both collaborators and research subjects;
- goals of facilitating public or stakeholder involvement;
- effects on roles and relationships from performing the collaboration;
- potential for modulating experimental research practice.

Operational features. Nanotechnology provides a convenient example of the similarities with our current practice and steps towards institutionalisation of such forms of collaboration. Early engagement is a feature of the approaches known as Constructive Technology Assessment (CTA) (Schot and Rip, 1997), and Real-time Technology Assessment (RTA), developed by Guston and Sarewitz (2002). Rip (2006: 362) notes that these approaches open up a new role for social scientists, who are being invited to interact with nanoscientists 'at a much earlier stage of developments than usual'.

While our collaboration did not start 'upstream' to the same extent as some nanotech programmes, it dated from the start of testing on human subjects, when design options were still at a fairly fluid stage. Likewise, although our work is on a circumscribed array of impacts, we share with CTA the acceptance in principle of societal aspects as additional design criteria, and a commitment to feeding user insights into decision-making and actors' strategies on a continuous basis.

Similarities with our practice are also visible in other institutional initiatives. In the USA, in one of several special Centers for Nanotechnology in Society set up by the NSF the nanoscientists are expected, or obligated, to take on a four-part role which includes an explicit commitment to 'serving as research subjects' both through reflective self-study and cooperation with in-house sociologists in social studies of their laboratories (http//:cns.asu.edu/network). This interestingly assumes easy co-existence between collaborative and research subject status, as well as including the notion of self-study. Empirical work by Fisher illustrates how the sociologists may work in collaborative fashion with nanoscientists to explore feasibility of interventions and act as facilitators to the reflectivity of the scientists themselves (Fisher et al., 2006b; Fisher and Mahajan, 2006c) and provides evidence of how this may result in changes to research practice.

In the UK and elsewhere, there are examples of research centres employing an 'embedded' sociologist to develop the capacity of (nano)scientists to incorporate social science perspectives into their research (Doubleday, 2005b; Wilsdon et al., 2005). We note that these examples however carry the implication that the role of the social scientist will be self-limiting over time as a result of collaborative learning (Doubleday, 2007).

In our own case the MPRs said they had gained heightened awareness of volunteers' needs and priorities through the collaboration, and that their work had benefited as they incorporated these considerations into their practice. Our interactive way of working fits with Doubleday's (2005a) comment that social scientists and (nano)scientists must be partners in a joint exploration of social and ethical issues. We also came to recognise how this joint learning process contributed to reshaping the collaborative relationship itself as roles were gradually redefined, and research practice modulated, as a result of collaborative interactions.

Conclusions

Our case study of one collaboration traces its trajectory from conception and early development to a maturity not entirely in line with our expectations. The causes of change lie partly in the natural rhythm of a scientific project where the excitement of early findings establishing the key parameters is often followed by a long period of consolidation and incremental accumulation of confirmatory data. This change in dynamics, apparent productivity and the flow of benefits was accentuated in our case by a gradual modulation of roles as findings and learning from the first phase of the project became incorporated into research practice.

It may be argued that our choice of collaboration between scientists as a model implies working to a scientistic framework that compromised any challenging STS agenda. Our account is presented as an example of how a collaborative model can work for certain kinds of 'interventionist STS' (with

relatively limited aims) and 'socially informed' natural science where both parties treat the intervention as an experiment which may or may not work out according to predictions (Zuiderent-Jerak and Jensen, 2007). It was also important that our collaboration was between autonomous individuals, each independently funded, each free to pursue their individual agendas alongside the joint endeavour.

Whereas we started off with a fairly conventional collaboration, we have gradually shifted to a more diffuse collaborative mode. Our initial judgements about the viability and usefulness of collaboration were framed within a largely traditional view of what constituted collaboration, and what the common currencies of collaboration were (mutual benefit, complementary skills, autonomy of partners, 'trading zones'). This held for Phase One of the project but came under question early in Phase Two. Our joint conclusion was that, whereas 'collaboration' usually implies collaboration on a specific piece of work, we had evolved into a more diffuse symbiotic relationship, manifested in an integrated way of working (with STS researchers functioning almost as members of the medical physics team until such time as the physicists are ready to take over this role themselves) and valued not so much for its potential to produce significant project-related joint products in the short-term, as for its contribution (by opening the door to user input) to the productivity of the programme in the longer term. We understand the role of the embedded sociologists in other disciplines to be geared to taking a similar integrated and gradual approach to collaborative working.

Our experience derives more general interest from widespread government moves to address concerns about 'science and society' through fostering and institutionalising new kinds of collaboration – especially social science/ natural science collaboration, notably in nanotechnology, but increasingly elsewhere, including the environmental field (Lowe and Phillipson, 2006), translational genomics (Atkinson-Grosjean and Farris, 2008) and proteomics (McNally, 2005). Similar concerns apply in the field of health care and health technology development, where greater patient and public participation has been on the agenda for many years (Oliver, 2001; Prior, 2003) and social science involvement has been a fruitful field for analytical reflection and periodic policy initiatives (Zuiderent-Jerak and Jensen, 2007).

Our experience of a natural science/ social science collaboration in the field of health technology research with human subjects suggests that a sustained, interactive, integrated, reflexive approach has a role to play in facilitating user involvement which can yield benefits for both research outcomes and volunteers' experience. The comparison with nanotechnology suggests that such an approach, incorporating some of the mechanisms beginning to be institutionalised in this and other fields – such as the embedded sociologist and early engagement, could be a useful addition to current models of interdisciplinary working in health technology and related clinical research settings.

Acknowledgements

Notes

1 We use the term 'volunteer' to cover both patients and healthy volunteers. We avoid the use of the expression 'research participants' since the meaning and reality of 'participation' is a matter under investigation (Corrigan and Tutton, 2006).
2 See for example *Science as Culture*, September 2007 (16:3); *Science, Technology and Human Values*, 2007 (31 & 32); *Social Studies of Science*, 2003 (33:3); 'Does STS mean business?', Said Business School, 2004, 2005, www.sbs.ox.ac.uk/news/archives/Main/Does+STS+Mean+Business+2.htm

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