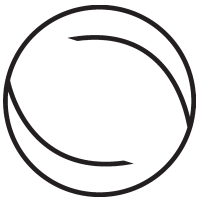

Inter-epistemic Power and Transforming Knowledge Objects in a Biomedical Network

Gerry McGivern and Sue Dopson

Abstract

We examine a multidisciplinary network established to translate genetics science into practice in the British NHS. Drawing on theory about epistemic communities and objects, we describe three stages in their lifecycle (vision/formation, transformation and reincarnation) and epistemic clashes over knowledge objects. Medical academics captured jurisdiction over the network at formation, through their superior knowledge of the nascent genetics discipline, producing epistemic objects reflecting their interests. A governmental community challenged medical academics for jurisdiction but, unable to transform objects by changing their space of representation in performance reporting, ceased funding the network, which then closed. Afterwards, however, a NHS community successfully 'reincarnated' a discarded epistemic object into a technical object in NHS practice. We make a theoretical contribution by developing a processual framework for understanding biomedical innovation, focusing on transforming objects situated between different wider knowledge/power structures. This explains how objects were transformed at micro-level through the interaction and relative power of local communities, influenced by macro-level rules about knowledge formation in wider epistemic, organizational and governmental communities.

Keywords: knowledge, objects, epistemic communities, networks, biomedical innovation

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Introduction

The University Genetics Knowledge Park (UGKP) is a multidisciplinary network established to translate academic knowledge about genetics into practice in the British National Health Service (NHS). Using theory on epistemic communities and objects, we consider the transformation of the network's objects in relation to the interaction and relative power of the local epistemic, organizational and governmental communities involved, themselves influenced by rules about knowledge formation in their wider communities.

In the first section of the paper we discuss literature on epistemic objects and communities, highlighting the lack of existing theory that explains how objects change. We then outline the processual qualitative methods we used to gather and theorize data. After introducing the GKP programme, the article offers a theoretical analysis of our case. We explain stages in the network (vision/formation; transformation and reincarnation) and a number of 'epistemic

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clashes' over objects. We make a theoretical contribution by developing a framework focused on transforming objects situated within wider knowledge/power structures, which transcends micro and macro levels of analysis. We argue that this may usefully explain the career of other multidisciplinary innovation projects.

Knowledge Objects

Theory about knowledge objects provides a useful lens on expert work because relations with 'objects' both reflect and affect social relations (Knorr-Cetina 1997). Practice studies often examine the meanings attributed to objects and individuals' and communities' relations with them (Orr 1996; Yanow 2006; Miettinen et al. 2009). Engestrom and Blackler (2005: 310) argue that 'organizations are built and maintained around partially shared, partially fragmented and partially disputed objects'. Accordingly, we use theory on knowledge objects to explain social processes within the UGKP.

Objects have been conceptualized in different ways in organizational theory. 'Boundary objects' are either physical objects or abstract concepts which exist as 'anchors or bridges, however temporary' between intersecting social worlds (Leigh-Star and Griesemer 1989: 414). Leigh-Star and Griesemer use the example of how different groups (including, for example, hunters and museum curators) relate to the same boundary object (e.g. a dead animal) in very different ways (e.g. as an exhibit or a hide). Boundary objects 'facilitate the reading of alternative meanings by different groups' (Sapsed and Salter 2004: 1519). Pinch and Bijker (1987) suggest that for objects ('artefacts') to become established (via 'rhetorical closure'), they must possess 'interpretive flexibility', so that different communities can conceive of them fitting with their own practices of constructing knowledge.

'Epistemic objects' are at the centre of 'different practices of creating and warranting knowledge in different domains', shaped by incentives and power structures within wider 'epistemic communities' (Knorr-Cetina 1999: 246). Knorr-Cetina argues that scientists do not represent reality but actively constitute it as knowledge objects through language. Rheinberger (1997) similarly highlights the importance of 'spaces of representation' in science.

Objects can be conceptualized as 'things' or 'processes', reflecting a wider debate (see Van de Ven and Poole 2005) about the conceptualization of organizations. '*Technical objects'* are things, which are fixed and stable (Knorr-Cetina 1997), tightly specified and determined within given standards of precision (Rheinberger 1997). Epistemic objects are 'processes and projections rather than definitive things' (Knorr-Cetina 1999: 6). Science is often 'incomplete' by design because the 'lack' of objects generates new research questions and facilitates scientific progress (Garud et al. 2008). Epistemic objects are therefore representations of 'a more basic lack of object' (Knorr-Cetina 2001: 181), characterized by 'irreducible vagueness' (Rheinberger 1997).

Objects can simultaneously exist in different forms (Knorr-Cetina 1997: 15). Boundary and technical objects tend to be fixed, concrete and transparent, whereas

epistemic objects are fluid, abstract and indeterminate, with an 'unfolding ontology'. So by definition epistemic and boundary objects or boundary and technical objects can simultaneously co-exist but epistemic and technical objects cannot (Ewenstein and Whyte 2009).

Engestrom and Blackler (2005: 313), drawing on activity theory (Engestrom 1987; Blackler 1993, 1995), highlight the 'transient', contextual and contested nature of objects, describing how objects move between being seen as useful or 'rubbish'. They also reflect on the lack of organizational theory on the transformation of objects. The biomedical network we examine in this article was created to transform epistemic objects (academic genetics science) into technical objects (healthcare services). Given that objects cannot be concurrently fluid (epistemic objects) and fixed (technical objects), and the lack of theory about transient objects, our case addresses interesting and problematic theoretical issues.

Biomedical innovation is explained in another GKP using the concept of knowledge objects. Swan et al. (2007) highlight the interactive nature of biomedical innovation, the role of professional and organizational boundaries and the use of different communities' power, using three vignettes around boundary objects. They highlight objects' symbolic importance, how they generate interest in projects and influence clinicians to change practice and how the different perspectives and interests of the communities involved affect the formation of knowledge objects. Following Engestrom and Blackler (2005), we build on Swan et al. by taking a more processual perspective on the transformation of knowledge objects, situated between multiple wider power/knowledge structures.

Indeed such practice-based analyses have been criticized for too narrowly conceiving of the structures of power practices are situated in (Contu and Willmott 2003). Macro-professional contexts shape knowledge at a micro-level (Robertson et al. 2003; Ormrod et al. 2007). Knowledge objects may be 'inscribed' with the interests of their creators. Scientists need to maintain a 'cycle of credibility' within their wider community (Latour and Woolgar 1986). This may involve conforming with wider structures of knowledge/power and 'rules of knowledge formation' (Foucault 2008: 42), although knowing can be unrecognized and surprising (Yanow and Tsoukas 2009) or embodied and unnoticed (Hindmarsh and Pilnick 2009).

Medical professionals have historically dominated healthcare through the 'indeterminate' (Jamous and Peloille 1970; Boreham 1983), tacit or judgement-based nature of their knowledge, practice and autonomous collective organization (Abbott 1988; Freidson 1994). The introduction of public managers and regulators challenged medical jurisdiction attempting to make healthcare more transparent and governable (Ferlie et al. 1996). As Rose and Miller (1992: 8) argue, such 'political rationalities have an epistemological character … articulated in relation to some conception of the nature of the object governed'. Governments may attempt to construct *governable* objects in opposition to 'enclosures of expertise', seeking to preserve the indeterminate nature of knowledge and practice.

'Jurisdiction' has commonly been analysed at an institutional or macro-sociological level (Abbott 1988; Freidson 1994). Bechky (2003: 722) argues

that 'while macrosociological processes influence jurisdictional outcomes, the task boundary is further specified through occupational interactions at the point at which the work takes place'. She argues that while objects are useful in problem-solving across boundaries, they simultaneously reinforce boundaries and serve as representations of occupational jurisdiction. Bechky (2003) suggests that objects reflect three interrelated dynamics of jurisdictional conflict: knowledge, authority and legitimacy. Examining various communities' use of objects in complex workplace and organizational settings (such as the NHS) provides 'a fuller picture of how occupational conflict is enacted in practice' (2003: 747), but few studies have examined jurisdiction at a micro-level.

We respond to Miettinen et al.'s call to transcend levels and understand practice, taking place simultaneously locally and globally. 'Practice studies' may require us to reconceptualize the idea of levels (Miettinen et al. 2009). We explore how complex micro-level interaction between professional, governmental and organizational communities, situated within wider rules for knowledge formation, affect the evolution and transformation of knowledge objects.

Methods

Given this longitudinal focus, we used a number of complementary processual and contextual research methods (Langley 1999; Van de Ven and Poole 1995, 2005; Pettigrew et al. 2001; Pentland 1999) to explore and make sense of changing interconnections between the contexts, content and process within this single case. Dyer and Wilkins (1991) note that many important theoretical developments have resulted from analysis of rich stories in single cases.

Drawing on Van de Ven and Poole's (1995) heuristic for understanding organizational change, we chronologically analysed the 'evolution' of transforming knowledge objects (described below), punctuated by key events marking 'phases' or 'stages' (vision, formation, transformation, reincarnation) in the network's 'lifecycle', which provided a natural timeframe (2002–7) for this research. Our analysis covers a period (2001–8), including time immediately before and after the network, involving events crucial to its understanding. This perspective and method provide a framework for studying the evolution of knowledge objects through distinct epochs.

We therefore gathered and triangulated three sources of qualitative data about the UGKP: Documents (the UGKP proposal, minutes of UGKP meetings, quarterly UGKP reports, Advisory Group minutes and interim reviews), observation of 25 UGKP executive and supervisor board meetings (2002–7) and 76 semi-structured interviews with a representative range of stakeholders involved in the UGKP. We interviewed 24 people in 2002–3 about the formation and early phase of the UGKP. In 2005–6 we interviewed 30 people, including 15 members of the Advisory Group that oversaw the regulation of GKPs. In 2006–7, we conducted a final round of 22 interviews to capture the overall UGKP story at its close. Finally, we presented results to the UGKP and the Department of Health (DH) to validate our findings. Table 1 summarizes the number of interviews among different stakeholders during the three phases:

Table 1. Interviews with UGKP Communities over Three Phases

Phase	Vision/Formation (2001–2)	Transformation (2003–5)	Reincarnation (2006–8)
Interview Dates	*2002–3*	*2005–6*	*2006–7*
Government/Policy Community	–	15	5
Medical Professors	5	5	3
NHS Doctors	5	5	4
NHS Lab Scientists	2	1	3
University Scientists	2	1	2
University Social Scientists	4	1	2
Commissioners	–	1	2
Others	4 NHS managers 1 Patient representative 1 University innovation manager	1 NHS manager	1 Patient representative
Total = 76	**24**	**30**	**22**

The way people 'talk about' objects (Orr 1996; Yanow 2006), organizations (Czarniawska 1998; Gabriel 1995) and change (Pentland 1999) both represents and constructs them and affects how people respond. Like Brown (1998), we pieced together the overall UGKP story from different stakeholders' narratives, comparing these accounts in the tradition of qualitative analysis around key points and phases in the network lifecycle. We then explain the antecedents and consequences of change within the UGKP, extrapolating from surface level descriptions to underlying generative processes (Pentland, 1999), including how wider epistemic, organizational and governmental regimes influenced objects. Stories can be generative, constructing as well as representing 'truth'. We acknowledge the potential subjectivity of our account (Pentland, 1999) but did validate it with UGKP stakeholders, so it does represent events within the UGKP in a way that participants recognize and indeed learnt from. Our findings could also be tested against other GKPs using the analytical framework we have developed.

We built theory 'iteratively' (Eisenhardt, 1989, Langley, 1999). Initially we surveyed theories (on knowledge, learning, networks and innovation) that might explain data within an early literature review. Theory on epistemic communities and objects later emerged as particularly useful because it enabled us to move from micro-level data (about objects) to discern wider structures we found in operation. We then moved iteratively between data and theory, linking the first-order UGKP story with new and pre-existing second-order theoretical codes, until we were able to explain the case theoretically in a way that was 'parsimonious, testable and logically coherent' (Eisenhardt, 1989: 548) and provided the best trade-off between accuracy, generality and simplicity (Langley, 1999).

Genetics Knowledge Parks

Mapping the human genome produced considerable hype around a vision of genetics revolutionizing health care, but in practice genetics breakthroughs have

been disappointing (Nightingale and Martin 2004; Sunder-Rajan 2006; Pisano 2006). Difficulties translating biomedical science into practice stem from uncertainty about biotech innovation, rooted in scientists' tacit knowledge and limited understanding of human biology, and the degree of collaboration among the occupations, organizations and disciplines involved (Pisano, 2006).

Networks appear important where genetics innovations have occurred (Powell et al. 1996; Liebeskind et al. 1996). Pisano (2006) suggests that biotech innovation may need additional public sector involvement, greater focus on scientific contribution within universities, and more interdisciplinary working. But Wainwright et al. (2006) point out that academics and health care practitioners, medics and scientists translate biomedical science in different ways and have different interests, and these differences often retard innovation. New modes of multi-disciplinary knowledge production can disrupt pre-existing knowledge bases (Strathern 2007) and epistemic or cultural differences between professions have been found to limit the spread of innovation and knowledge sharing in health care (Ferlie et al. 2005; Dopson 2005; Dopson and Fitzgerald 2006; Wainwright et al. 2006). Yet government policy has previously overlooked the consequences of these differences for NHS knowledge management (Currie and Suhomlinova 2006).

The GKP initiative was launched in 2002 as a major part of the British Government's strategy for realizing the potential of genetics science and biotechnology to improve the health and wealth of the nation, reflected in the DH's subsequent White Paper (Department of Health 2003). The DH and Department of Trade and Industry (DTI) jointly invested £15,000,000 over five years in six GKPs to promote interdisciplinary networking and the translation of science into practice. The concept of the GKP can be seen as symbolizing the Government's message that advances in knowledge can be achieved by different communities collaborating and sharing knowledge (Swan et al. 2007).

The UGKP was a transient organizational structure:

> A temporary structure … [until] the Department of Health decides the next trendy thing to do … a pilot, and then it will all disperse. (academic scientist)

> A process of evolution. It evolved in an extremely loose way … what we ended up with as a network wasn't in any way thought out in advance. (medical professor)

We conceptualize the 'work packages' (described later) within the UGKP as knowledge objects, situated within wider epistemic, occupational and organizational communities, including:

- *Medical professors* from a university department of medicine
- *NHS doctors* within a NHS hospital
- *Academic scientists* in a university research institute, trained in biological science
- *NHS scientists* in NHS laboratories, trained in human biology, conducting genetics testing
- *Academic social scientists* within a university social science institute

- *Policy-makers*, including the DH and DTI, civil servants and members of an advisory group (containing genetics experts from medicine, science, social science and the pharmaceutical industry)
- *NHS commissioners* responsible for funding NHS services

Having provided definitions and background on GKPs, we now describe phases in the UGKP story.

The 'University GKP' Story

The GKP Vision

The DH published national tender documents in 2001, proposing six GKPs and outlining the Government's desire to create networks to facilitate the translation of academic genetics science into NHS practice. However, the vision for GKPs was vague. A DH official commented:

> [GKPs] appeared very late in the drafting of the NHS plan … just a throwaway sentence that took everyone by surprise and when [the then Health Secretary] was questioned what it was, he said, 'You tell me.' We then had to develop some themes. We felt GKPs were about focusing on an aspect of genetics knowledge and really becoming a centre of excellence, a world leader … The objective of the GKPs was to prepare the NHS for the genetics revolution … it rolls off the tongue very easily, but what does it actually mean?

A DH official acknowledged that funding research was risky, with unknown outcomes, but argued that the benefits of the few projects that succeeded outweighed the costs of the majority that failed:

> Translation … like most research … 90% of it is just adding to general knowledge … but the odd 10% really makes a difference … pays for the whole cost of that programme … but you don't really know the outcome.

Reflecting Rheinberger's (1997) notion of scientific 'vagueness', the GKP tender was 'shrouded in vagueness' (medical professor) and 'there really wasn't any specific guidance' (genetics professor). This provided considerable 'interpretive flexibility' (Pinch and Bijker 1987) for those submitting bids to develop their own ideas around the 'GKP model'.

The short timescale for submitting bids reduced forethought given to the bid, which was seen as:

> Completely crazy … a proper science application would never do things on such a short timescale. (genetics professor)

At the local level, the UGKP vision involved collaboration between a university and a nearby NHS hospital. The university contains a number of leading biomedical academics, with international reputations and networks. The university's clinical genetics department is linked to the NHS hospital, which contains a research laboratory (labs hereafter) offering genetics testing services to the national population. The opportunity of funding pushed research and clinical practitioners closer together. The medical director of the NHS hospital and its

labs' directors became involved with the UGKP bid, which they saw as providing new funds, equipment and raising their national profile and credibility.

Other medical professors were approached for their reputation and credibility, as the DH 'wanted prominent geneticists on the bid' (DH director). As a medical professor commented, 'clearly we were a very competitive bunch'. So the bid was dominated by the 'great and the good' in the university medicine department, a leading genetics professor 'and his mates' (NHS scientist).

The speed of the bid worried NHS hospital staff. An NHS manager commented:

> The bid got rushed through. It didn't really have the opportunity to go through the correct channels … There was a concern it was a cavalier process.

Another NHS manager expressed concern about the UGKP at an early stage: 'I have little expectations partly because the people who are active in the GKP want to do their science, not influence services.'

NHS doctors too 'worried about the question of how it is going to impact on the patients we see' and reported 'a huge gap between academic and clinical genetics' (NHS geneticist).

In theoretical terms, the indeterminate nature of the GKP tender and the nascent genetics field enabled university medical professors to capture jurisdiction over the UGKP: 'genetics was the province of the clinical researcher and the academic researcher' (DH official). GKP funding provided an opportunity to 'do their science' and create epistemic objects (academic publications) and credibility within their epistemic community:

> It became fairly clear that we might be able to fund an area of work that I was having difficulty in covering … in very pragmatic terms … GKPs are very attractive as a resource. (cardiology professor)

> It provided additional, terribly useful funds to do the work we wanted to do but it was maintaining the momentum we were building elsewhere. (pathology professor)

> The GKP means nothing; it's a way of getting money into clinical practice. (genetics professor)

So for medical professors, the UGKP vision was a means of funding academic research almost regardless of its espoused purpose.

The UGKP Formation

The UGKP won funding and was established in 2002. The UGKP was a virtual organization with members from a range of disciplines, who either worked part time for the network or were employed on temporary full-time contracts. They came together for regular meetings but were physically hosted separately within university departments and the NHS hospital. The UGKP assembled an executive board (including a network director with a background in academic science and a medical professor as chair) to actively manage the UGKP and a supervisory board, including representatives from a range of stakeholders involved in genetics translation. Many of the medical professors originally named on the UGKP bid played supervisory roles but strongly influenced the UGKP.

The UGKP's efforts were split into four 'work programmes' (WPs) largely based on the university's core competencies. We focus on WP1 – the development of a clinical service for the identification and genetic management of

inherited sudden cardiac death (SCD) syndrome (cardiovascular genetics). WP2 related to the viability of routine molecular testing for low penetrance genes influencing susceptibility to disease and/or response to treatment (cardiovascular genetics). WP3 focused on the development of genetic microarray technology. WP4 involved social science relating to the ethical, economic, social and legal factors in the translation of the other WPs, which we examine in relation to WP1.

WP3 made some translational progress but became redundant as cheaper alternative microarray technology was developed commercially elsewhere. Reflecting NHS fears, there was little interdisciplinary networking or translation in respect of WP2:

> I can't see that they actually made any progress from the beginning of the knowledge park to the end … lots of testing but I don't know that there has been anything achieved from it. Perhaps they have just succeeded in disproving something that previously had been published. (academic scientist)

Yet the cardiology professor leading WP2 regarded its outcome as:

> Very good science … we'll have good publications and will be internationally well regarded by peer-reviews.

Likewise, another medical professor commented:

> We are generating results now that we wouldn't be able to do if it had not been for the GKP … academic type of stuff leading to more grants, more publications … I would say it [the GKP] is a success … [Translational networking] is almost irrelevant.

So although the DH believed these WPs had failed in terms of translation, they were successful for medical professors, who, in theoretical terms, were focused on creating epistemic objects (science and publications) providing credibility with their epistemic community (international academic medical peers) and boosting their 'cycle of credibility' (Latour and Woolgar 1986), producing further grants and publications.

Transforming the GKPs' Space of Representation

The six GKPs that were funded were left to translate objects into practice but the DH and DTI were 'quite disappointed' (DH official) with their progress two years in. The DTI declared early on that it would not be refunding GKPs and withdrew its role managing them. The DH remained more optimistic but acknowledged it had little understanding of the GKPs. The ambiguous tender meant that desired outcomes were unclear and the decision to invest in six different GKPs made comparing progress on a like-for-like basis difficult. Demonstrating resources were being used effectively was also problematic, particularly due to GKPs' inter-disciplinary nature (Rockhill Khlinovskaya 2007).

To help evaluate GKPs' performance, the DH established an advisory group, containing genetics experts from a range of institutions (including the DH, universities and the pharmaceutical industry) and disciplines (including medicine, biology and sociology), which met for the first time in March 2003. The advisory group strengthened the policy community, enabling it to challenge medical professors for jurisdiction over the GKPs; its formation heralded a key moment of transition for the UGKP too.

The DH imposed standardized quarterly performance reviews on GKPs. A DH official commented: 'The collective way of reporting across the six GKPs made the work of the advisory group quite easy … criteria were used to make assessments.' An advisory group member similarly noted 'reporting in a particular format so that we could judge performance against criteria', which related to translation into practice rather than academic progress. In theoretical terms, the DH was attempting to change the 'space of representation' (Rheinberger 1997) by introducing a form of 'governmentality' (Foucault 1991).

Several interviewees associated quarterly reporting with a 'sea change' and the advisory group 'getting to grips' with their role. By the end of 2004, the DH and advisory group were 'able to engage and pick up some of the problems' (DH official) with GKPs. Reports showed evidence of translational failure. But controlling this space of representation did not lead to jurisdiction over GKPs. UGKP medical professors and scientists contested the legitimacy of representing objects in reports, which they argued was a 'changing of the rules' midway through the funding period. They also suggested that the advisory group were unclear about what the GKPs should achieve and provided little guidance about objectives, targets or methods of reporting. Moreover, they believed that quarterly reports (containing temporal and governmental spacing) could not represent the slow pace and complexity of genetic innovation. Interviewees found reporting time-consuming and feedback limited, vague and unconstructive, which led to perceptions that reports were 'a box ticking exercise':

> Even though it is a quarterly report … it seems like you blink your eye and the next one is due … constantly doing something that is wasting your real time. You are ticking bureaucratic boxes. That is how it feels … All you end up doing is write pretty much the same as last time and then you change a few of the numbers. (academic scientist)

A scientist on the advisory group commented:

> I would have appreciated smaller group meetings [with GKPs], it might have given us more insight into what was going on rather than relying on the papers [reports] … we didn't spend time trying to facilitate learning, it was more a judgemental method.

Rather than facilitating dialogue between the medical, scientific and policy communities, reporting was superficial 'tick box' compliance. As found elsewhere in NHS regulation (McGivern and Ferlie 2007; Waring and Currie 2009), this undermined the motivation of medical professors and scientists:

> Formal reporting … is painful, time consuming, money consuming, energy consuming and often you end up with the same results … I assume that someone reads them [reports], which is dull and boring for them, but it is worse for us to have to collate that and agree it. (medical professor)

Quarterly reporting led to an impasse between the DH and UGKP. The medical professor leading WP3 left the university, delegating responsibility to an academic scientist. At the same time, the DH began considering whether GKPs were worth funding. Reporting exposed fundamental clashes in how the policy-community and academics represented objects: in theoretical terms, clashes between regimes of government and regimes of practice. The policy community needed to represent governable technical objects (demonstrating translation within a reasonable timeframe), whereas academics needed to develop epistemic

objects (academic publications), as well as to attend to the translation agenda, to maintain credibility within their epistemic communities. So both expert and governmental regimes affected the transformation of objects.

Epistemic Clashes within the UGKP

Pressure to demonstrate translation also strained relationships within the UGKP, triggering epistemic clashes between academics and NHS scientists:

> There is obviously some conflict between research and providing a diagnostic service. (academic scientist)

Academic scientists argued that NHS scientists did not understand research:

> There was this perception that basically you just do three months work and they think it is easy to write a paper … we weren't even considering that much research to be enough for publication … we do experiments which last months … they do the work of numbers … I suppose quite quickly … they feel that they are providing a service and being careful and we are feckless people who wander in at eleven o'clock and go home at three and generally … look for all the glory. (academic scientist)

A NHS scientist in turn complained about academics' attitudes towards NHS scientists: 'when [academic scientist] says the *routine* lab, I mean I could shoot her.' She argued that lab-based NHS scientists were 'just as good' as academic scientists in the university, had 'the same background' but had 'chosen a different career'. So despite a common biomedical epistemology, varying career structures within different organizations created fundamental differences over notions of legitimate objects and credibility.

This clash was represented in 'frustrations in terms of turn around times' (NHS doctor). Lab-based NHS scientists aimed to create reliable objects, meaning that test results were produced much more slowly than the medical professors and academic scientists wanted:

> They don't want to be sued and for somebody to come back to them in five years time and say you said x when officially it was y … in these labs if one mistake has been made along the way … they put in all these structures to counter that happening again, but if it has only happened once in 500 samples and you put in all of this structure you are just bogged down. (academic scientist)

Academics needed to get results quickly, as a genetics professor commented:

> We are competing with the best in the world, and frankly we are not funded to compete with them, so we need to use every intellectual trick in the book.

So credibility within epistemic *and* organizational regimes affected scientists' attitudes towards the SCD test. Quick but possibly inaccurate test results could undermine the lab's credibility, whereas slow results could undermine university researchers' competitiveness and credibility.

A NHS doctor notably overcame the conflict between the NHS labs and university. He was seen as 'having academic aspirations' (NHS doctor) and described himself as 'a sort of buffer', having previously worked closely with WP1 Lead (a medical professor) in the university and also within labs:

> I spend a lot of time working in the lab … I knew exactly what they were talking about … they would understand the need for speed but at the same time I understood their need for accuracy.

This NHS doctor had the interpersonal skills, credibility and a passion to improve patient care and he facilitated a transformation in WP1 working with academic and NHS scientists, as we will describe later.

A second clash between university researchers and the NHS labs emerged in relation to WP4 (social science). National competition between different NHS labs began to undermine the labs' willingness to disclose cost information to a health economist (social scientist) in the UGKP, who was trying to calculate the national health economics of SCD testing. The labs feared this information might leak and undermine their competitive position:

> She's not very willing to be open about process costs, competitiveness, comparative costs in the lab, I think because she worries that that puts her in a commercially weakened position. (cardiology professor).

The network director (an academic scientist) complained that the NHS labs were 'protecting their own patch', whereas 'the important thing is patients getting tests'. The NHS scientist running the labs admitted that she was 'worrying … the NHS is changing into a more competitive culture'. The health economist (social scientist) expressed frustration about the labs' uncooperative behaviour, particularly because other labs outside the UGKP *were* willing to provide this information. An academic scientist commented:

> Health economics … were trying to do costing … [NHS scientist] basically didn't want to give any prices … a complete barrier … embarrassing because you have got [NHS labs in other universities] collaborating.

Again we see the importance of organizational *and* epistemic structures affecting the transformation of objects.

The health economist was more able to engage medical professors and academic scientists, partly because they shared a common academic quantitative epistemology and they could understand the tangible value of her work. This contrasted with the work of a sociologist (also a social scientist working on WP4), who was seen as doing 'weird' and 'woolly' research:

> I can understand the economics side of things and it is very interesting … see how it is applied … The sociology side of things would be the hardest to … understand because it just seems so vague … not exactly on science … you can take any opinion and just mould it into a report. (academic scientist)

> Our world is very black and white … [Sociologists'] terminology, it doesn't mean anything to us … it was quite obvious we were providing material … to write some interesting papers. … It was not of mutual benefit. … It was a one-way flow … a clash between people coming from a scientific point of view, or what you feel is scientific, and things that are not. (academic scientist)

So the sociologist's construction of objects was perceived as 'unscientific', difficult to apply in practice and offering little benefit in exchange with scientific collaborators. When it became clear that his position would not be refunded, the sociologist withdrew further into his epistemic paradigm, producing sociological papers (epistemic objects) valued by his sociological community, which provided the credibility he needed to get an academic position elsewhere. Again, conforming to epistemic communities' rules for knowledge formation remained paramount. However we also see differences between the perceived validity of

the health economists' and sociologists' social science and their ability to relate to academic scientific peers.

By early 2005, medical and academic scientists working on WP1 (with the help of the health economist working on WP4) had successfully collaborated to create an epistemic object valued by their epistemic communities – an academically proven genetic test for SCD. However, as a NHS doctor put it:

> They sit round in the Knowledge Park, all the academics and university boys, and pat each other on the back and say I have done a fantastic job … [but it is] not being translated until he [the commissioner] sends that cheque. (NHS geneticist)

The DH increased pressure to translate this (still epistemic) object into NHS practice (become a technical object). But translating academically proven epistemic objects into practice provided the academics involved little credibility in the world they sought to influence. Translation into practice depended on key middle-level professionals working 'at the coalface' (NHS scientist): two NHS geneticists, two academic scientists, the health economist (social scientist) and two NHS scientists. This small group, led by the NHS doctor discussed earlier, 'engaged' with the vision of translating the SCD test into practice, beginning a conversation with a NHS commissioner responsible for funding local health services about how the SCD test could be commissioned as a NHS service, but failed to reach agreement. Different sources of credibility within wider communities appeared important for NHS commissioners too. One commented:

> If you have got credibility you can influence way beyond your status … you are an important player in the system and actually you are somebody they need to debate and talk to.

He went on:

> The biggest problem … is the language and where we are each coming from ... tension … between clinicians and commissioners … the clinician is there to do the best for the patient in front of them. The commissioner … the best they can for the entire population. … You are moving from single gene testing to population type testing. … The test might be wonderful ... but … I don't want 150 cardiologists all thinking it would be a good idea … because we can't afford it.

Medical professors, academics and NHS scientists viewed WP1 in different ways from the NHS commissioner:

> Preventative medicine doesn't appear on the balance sheet as a plus, so trying to persuade them [commissioners] … is a bit tricky … it doesn't meet government targets, there isn't an outcome you can measure, which the government can understand. (medical professor)

> This sudden cardiac death thing is up and running in the labs … I have got the impression that there is a problem funding it because it is cheaper to let somebody die. (academic scientist)

> If we didn't do the test and the patients died they are not going to cost the NHS money. (NHS scientist)

Although the test was proven as a clinically and economically viable object, it had implications for limited local budgets. Testing people with a family history of SCD would be expensive, not least because those at risk would need costly defibrillators. When at the end of 2007 we gathered final field data, as the UGKP closed, the local commissioner had not been convinced of the SCD test's clinical

and economic benefits, which he regarded as 'academic'. So, once again, we see organization and epistemic structures affecting the transformation of objects.

Object Reincarnation

By mid 2006, the DH had decided not to continue funding the wider GKP project despite an implicit (mis)understanding within the UGKP that funding would continue beyond the initial five-year period. None of the six GKPs had demonstrated sufficient progress in translating academic science into practice. Although the GKPs, particularly the UGKP, had made academic progress, the DH argued that there were more appropriate means for funding science:

> A question is, whether that would have happened without the … funding, I suspect it would … what's the value added? … Most academic medical researchers have no concept of how you actually do that translation. (DH official)

An advisory group member similarly commented:

> Many of the academics don't seem to focus on the deliverables in the NHS and that has been my experience of the GKPs … a lot of the academic work going on would have gone on naturally and it wasn't going to benefit the NHS … they need to focus on the end game … the lack of translational awareness was disappointing.

At the time that the DH was deciding to close the UGKP, the university had been bidding for a new biomedical research centre, which it won funding for and into which UGKP epistemic objects were 'reincarnated'. In 2008, after all the GKPs closed and medical professors and policy-makers had given up jurisdiction over its objects, we heard that WP1 was translated into a technical object in NHS practice. The small group of NHS doctors and scientists involved in WP1 (which we discussed earlier) had apparently remained 'engaged' with developing a NHS SCD testing service, despite there no longer being DH pressure to deliver translation. They eventually convinced a new NHS commissioner to fund the service. In Engestrom and Blackler's (2005) theoretical terms, this 'rubbish' object, discarded by medical professors and the DH, had finally become useful.

Discussion

Our analysis highlights the ways multiple communities shape the transformation of objects and responds to Engestrom and Blackler's (2005) call for theorization about the transformation of objects. Developing particular forms of knowledge, providing credibility within wider epistemic communities, appeared to determine members' orientations to the UGKP's objects. These objects were created at the interstices between epistemic communities, governmental regimes and organizational structures. Table 2 summarizes the epistemic and organizational affiliation, sources of credibility and orientations towards objects for the different communities involved in the UGKP.

The transformation of objects depended on communities' relative power to affect the UGKP's 'space of representation' (Rheinberger 1997) and shape objects to fit with the rules of knowledge formation providing credibility within wider communities. As in other GKPs (see Rockhill Khlinovskaya 2007; Swan

Table 2.
UGKP Communities and Their Orientations towards Knowledge Objects

Community	Epistemic Affiliation	Organizational Affiliation	Sources of Credibility	Object Orientation
Medical Professors	Medicine	University	Biomedical publications & research grants	Epistemic (Academic)
NHS Doctors	Medicine	NHS hospital	Delivering & developing NHS services & patient care	Technical (Practical)
Academic Scientists	Biology	University	Biomedical publications & research grants	Epistemic (Academic)
NHS Scientists	Biology	NHS Labs	Maintaining credibility for reliable testing & NHS 'market' share	Technical (Practical)
Social Scientists	Social science	University	Social science publications & research grants	Epistemic (Academic)
Policy	Policy (various)	DH (& various)	Delivering demonstrable policy outcomes	Governable (Technical)
NHS Commissioner	Management (finance)	NHS PCT	Delivering NHS services within budgets	Governable (Technical)

et al. 2007) and biomedical translation projects (Wainwright et al. 2006), there was ultimately little overlap between the objects academics (medical professors, academic scientists and social scientists) and the NHS (NHS scientists, commissioners and policy-makers) wanted to construct. This produced what we describe as 'epistemic clashes' over objects. University-based academics need to create epistemic objects (academic publications) providing credibility within their epistemic communities. NHS scientists need to create technical objects (reliable tests) maintaining NHS credibility and market share. Commissioners wanted to create governable technical objects (NHS services) within budgets, while the DH sought governable technical objects, which demonstrated policy delivery (translation of science into NHS practice) within a determinate timeframe.

We describe three stages of transformation within the UGKP's lifecycle: first, from *vision to formation*. The *vision* of co-constructing knowledge objects within the UGKP offered members of different communities the prospect of resources and credibility. The different perspectives and interests of the communities involved in other GKPs appeared to affect knowledge formation too (Swan et al. 2007). Medical professors captured jurisdiction over the UGKP, as a consequence of both the vague GKP tender process and their superior knowledge of the nascent and indeterminate genetics discipline. Consequently, they *formed* the UGKP to do 'their science', constructing epistemic objects producing credibility within their wider epistemic community.

In the second stage, the DH attempted to capture jurisdiction over the GKPs, first by improving their knowledge of genetics, drawing in the expertise of the advisory group, and second by making GKP objects more governable

by *transforming* their space of representation in quarterly reporting. This can be seen as a form of governmentality (Foucault 1991). Medical professors and academic scientists contested the legitimacy of this space of representation, drawing upon their expertise to claim that genetics innovation was more complex, indeterminate and slowly evolving than reporting could reflect. Credibility within their wider epistemic community, and 'enclosure of expertise' (Rose and Miller 1992) appeared to provide the means and motivation to evade governmentality.

We label the third stage *reincarnation*. The DH decided not to re-fund the six GKPs because they had not translated academic objects into NHS practice quickly enough and the UGKP closed. However, afterwards, NHS doctors and scientists involved in the discarded epistemic WP1 object convinced a commissioner to fund a NHS SCD testing service, creating a technical object. Other WPs were also reincarnated as epistemic objects into a new university biomedical research centre.

As object theory (Knorr-Cetina 1997, 1999; Rheinberger 1997; Ewenstein and Whyte 2009) predicted, epistemic and technical objects remained mutually exclusive throughout the UGKP lifecycle. The dominant community of medical professors maintained jurisdiction over the UGKP and its WPs remained epistemic objects. However, our findings resonate with Engestrom and Blackler's (2005) point that objects are transient and that 'rubbish' objects can become useful. Ironically, only after the UGKP's epistemic objects had 'died' within the medical professors' and policy-makers' spaces of representation, accordingly freeing them from these wider structures shaping their formation, were they 'reincarnated' as technical objects within the NHS.

Conclusion

Biomedical innovation has not lived up to the hype about it revolutionizing health care. Greater interdisciplinary collaboration, involving the public sector and universities, was proposed as a solution to this problem (Pisano 2006), but there is little empirical research on such initiatives. We examined one such network, funded to translate academic genetics science into practice.

Research (Swan et al. 2007) has previously examined knowledge objects in a GKP, explaining how the perceptions, interests and power of those involved affected them. We too explore how these factors affected UGKP objects but, rather than using Swan et al.'s static vignette-based analysis of boundary object between two communities, take a processual perspective on *transforming* objects situated between *multiple* wider structures of knowledge/power. Our paper responds to Engestrom and Blackler's (2005) call for theorization about the transformation of objects. We also address the theoretical paradox of how epistemic objects (science), which are by definition 'incomplete' (Garud et al. 2008), vague and fluid processes, can become technical objects (NHS services), which are by definition fixed and stable (Rheinberger 1997; Knorr-Cetina 1997; Ewenstein and Whyte 2009).

Objects were transformed at the micro-level through interaction between several local epistemic communities, each influenced by different wider epistemic,

organizational and governmental rules for knowledge formation. The most powerful community (academic medical professors), captured and retained jurisdiction over the UGKP and the space of representation for objects (Rheinberger 1997), through their superior knowledge of the nascent genetics discipline. They produced epistemic objects that reflected forms of credibility valued in their wider community. The governmental community unsuccessfully challenged medical professors by changing the space of representation for objects, and then decided to cease funding the network. Medical professors consequently lost interest in the UGKP, 'reincarnating' epistemic objects into a new biomedical research centre. Only then was an epistemic object successfully transformed, or rather 'reincarnated', into a technical object in NHS practice (a NHS SCD testing service) under the jurisdiction of a weaker NHS community, more interested in providing NHS services. Our findings suggest that objects do not disappear but that the 'death' of objects, freeing them of wider structures of knowledge formation and power, is an important stage in their transformation.

Our case highlights the importance of processual research focusing on transforming objects (even before and after their organizational settings formally exist) situated between different wider structures of knowledge/power. It demonstrates the need to transcend micro and macro levels of analysis and provides an example of how practices simultaneously take place locally and globally (Miettinen et al. 2009). Without these elements of analytical framing, we would have missed key elements in this network's story. Accordingly, starting by testing this framework and our findings in other GKPs would be interesting. We suggest that examining transforming knowledge objects at micro-level, while simultaneously looking at the wider structural incentives and sources of credibility that motivate different professionals to produce knowledge, may make successes and problems in biotechnology innovation more predictable.

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