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Mind the Gap: The London Underground Map and Users' Representations of Urban Space

Janet Vertesi

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ABSTRACT   This paper explores the effects of iconic, abstract representations of complex objects on our interactions with those objects through an ethnographic study of the use of the London Underground Map to tame and enframe the city of London. Official reports insist that the 'Tube Map's' iconic status is due to its exemplary design principles or its utility for journey planning underground. This paper, however, presents results that suggest a different role for the familiar image: one of an essential visual technology that stands as an interface between the city and its user, presenting and structuring the points of access and possibilities for interaction within the urban space. The analysis explores the public understanding of an inscription in the world beyond the laboratory bench, the indexicality of the immutable mobile's visual language, and the relationship between representing and intervening. It further suggests fruitful crossovers between Science Studies, Urban Studies, and Human–Computer Interaction by approaching the individual as a 'user' of a city and its graphical interface, applying the technique of cognitive mapping to overlapping virtual and analog spaces, and exploring the social and practical effects of strong and standardized visual languages on further narratives and interactions with scientific, technological, or everyday objects.

keywords   cities, imaging, immutable mobile, maps, representing and intervening, visual language, visualization

Mind the Gap:

The London Underground Map and Users' Representations of Urban Space

Janet Vertesi

> When he had first arrived, he had found London huge, odd, fundamentally incomprehensible, with only the Tube map, that elegant multicolored topographical display of underground railway lines and stations, giving it any semblance of order. (Gaiman, 1996: 8)

> Most of what we call 'abstraction' is in practice the belief that a written inscription must be believed more than any contrary indications from the senses. (Latour, 1990: 51)

> Along with Tower Bridge and Big Ben it is the most widely recognized symbol of London. (Halliday, 2001: 145)
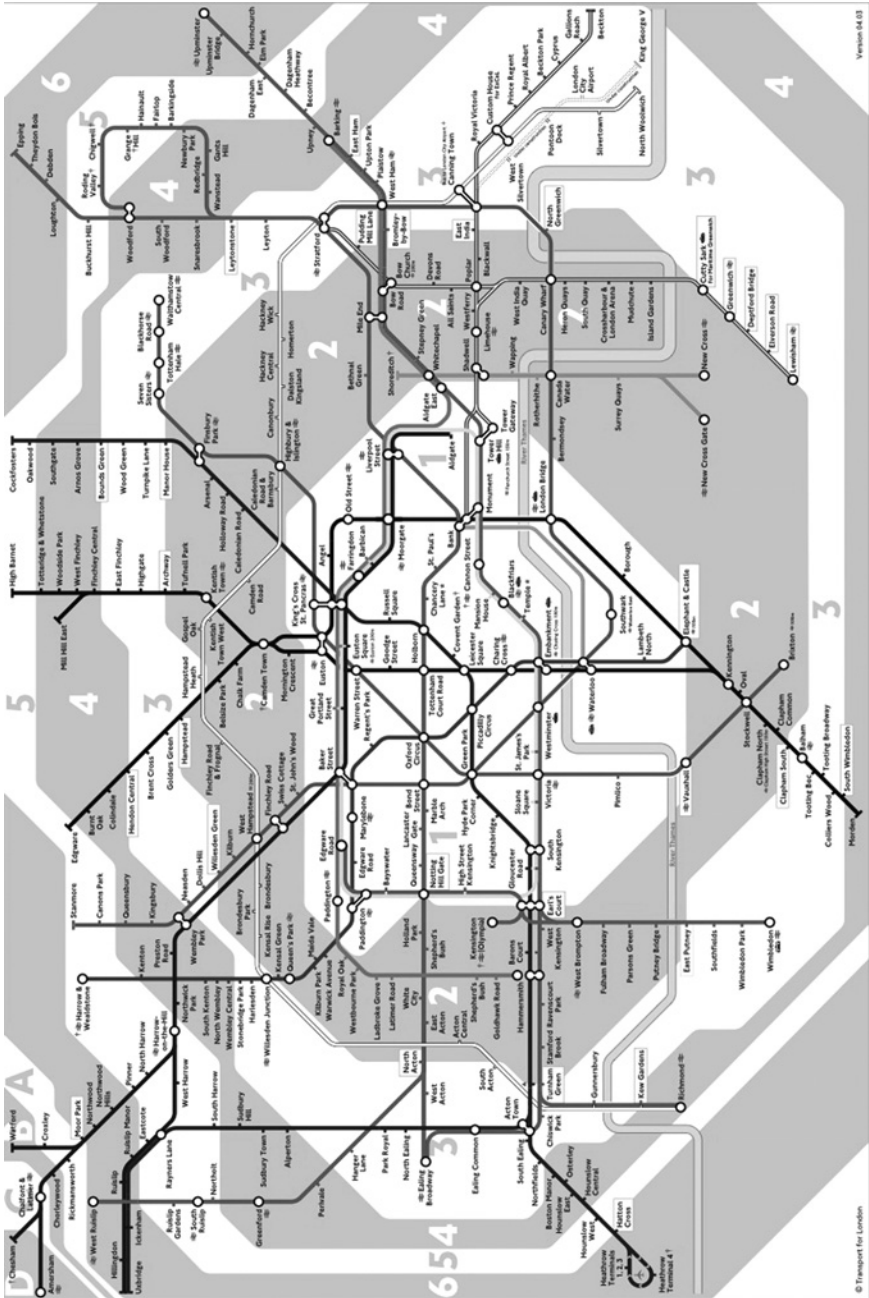
FIGURE 1
The London Underground Map. ©Transport for London.

No visitor to London can avoid the ubiquitous London Underground Map (Figure 1); like many public transit maps, it is regularly posted on city streets outside stations, and strategically placed inside train cars and on platforms at regulated locations and angles for maximum exposure. But the map exceeds the confines of the transit system: the famous design is plastered all over the city on tourist trinkets such as T-shirts, mugs, umbrellas, lighters, and postcards, and an estimated 95% of Londoners are said to have a copy at home.[1] It is no wonder that this map is often referred to as a modern icon, a symbol of London, representing not just the subway but even the city itself. Recognizing this fact, officials at the city's transport authority office, Transport for London, are always careful to call it a 'network diagram' or a 'journey planner', and they point to its trademark design principles, laid down by Harry Beck in 1932,[2] as the reason for its fame in the design world, its influence on subway maps worldwide, and its ease of use.[3] But this representation does other work for the Londoners and users of London I spoke with during my own study of the map in London. They call it 'the Tube Map', and while these users were careful to state outright that it did not properly represent the geography of London, this paper will examine how they rely on this representation to tame and enframe the chaotic city above ground. Thus, while the famous call to 'Mind the gap' usually refers to the gap between the train and the platform, this paper will recall another gap: between the iconic, abstract London Underground Map, and users' stories and practices of navigating, experiencing, and representing the city of London.

We rarely see a city as a whole without some kind of technological mediation: we walk, bike, or drive through the tangle of streets; we stand on top of tall buildings or at a publicly-developed lookout point to gain a city-sanctioned view, or we peer down at the landscape from airplane windows.[4] But another essential technology that mediates between the city and its users is a technology of representation: the map. Whether walking or driving along city streets, maps show us where to go and how to get there, serving as sites of interaction and active interpretation as well as wayfinding devices *in loco*.[5] But do these representations structure our expectations, narratives, or even our interactions and interventions with the city itself? If so, what traces of this relationship between representations of and interactions with the city can we discern?

The London Underground Map presents a unique case through which to explore these issues. Unlike Paris or New York, London above-ground presents few organizing principles: there is no Rive Gauche or Central Park, no grid or *arrondissement* system that provides the critical landmarks for wayfinding and making sense of the urban geography. The tangled medieval core of the city, rebuilt with few changes after the Great Fire of 1666, remains intact, and as of 1996 there were more than 50,000 streets registered (Ackroyd, 2000). The subway map itself is further unlike those of Paris or New York: lines are traced on a blank background instead of superimposed on a map of the city with streets and major landmarks, and the cartographic projection is non-traditional, inflating the centre and

conflating the periphery. The map is also highly stable in this singular view: it is so heavily copyrighted and controlled by the London Underground Limited branding regulations that alternative views of the network are strictly prohibited and rarely seen by Londoners.[6] Further, the abstract diagram is always presented alone, unlike other subway maps which may present a Londonesque diagram alongside or drawn atop a street map: a representational move that recalls Michael Lynch's (1990) comparison of microbial photographs and schematized drawings. Thus the London Underground Map presents an interesting case for science and technology studies, both in establishing a fruitful analogy to scientific illustration, and paying close attention to the ways in which a subway system map can make a city 'imageable' (Lynch, 1960).

Critical Questions

Studying the map of an urban subway network brings together several strands of research in science and technology studies and urban geography. Seminal works in cultural studies of geography emphasize and illustrate the knowledge, power, and politics inherent in maps and map-making.[7] To discuss the constructions of urban space, we can point to De Certeau's work on 'walking the city' (1984), or the recent addendum by Thrift on 'driving in the city' (2004). Schivelbusch's (1986) classic book on 19th-century railway systems established a way to talk about how technology may transform the physiological and psychological experience of geography, themes which echo in Bull's (2000) contemporary work on the use of personal stereos in the urban environment. Subway networks themselves draw our attention not only because they constitute a 'large technological system' (Hughes, 1987), but also because of the considerable skill, co-ordination, and 'heterogeneous engineering' (Law, 1987) needed to operate them.[8] In another vein, Thomas Gieryn (2006) explores the city as 'truth-spot' for the Chicago School of Urban Studies, while Anique Hommels (2005), and Eduardo Aibar and Wiebe Bijker (1997) have discussed the city as a large and complex socio-technological system, Hommels arguing for the application of STS principles to the study of cities in general.[9]

While I am indebted to these sources in too many ways to detail, this study of the Tube Map will speak primarily to critical issues in representation in science. As such, it parallels Lynch & Law's (1999) study of birdwatching: exploring a site of analysis that may appear tangential or extra-scientific, but which has significant implications for how we understand complex uses of the visual in science. Two particular themes are at stake here.

First, this paper explores how inscriptions work *in the world*, not just at their sites of production. Latour (1986), Lynch (1990), Knorr-Cetina & Amann (1990) have described the use of images at the lab bench, and Rudwick (1976) has discussed disciplinary visual languages in formation, but it is also important to study how images are employed *outside* of an inner circle of experts by an active public with a particular kind of user expertise.[10] In this move into a more public space, even such a stable image

as the Underground network diagram – with more than 15 million pocket versions printed each year[11] – may remain unchanged, but take on new meaning in a strange twist of the usual 'immutable mobile' story.[12] The map is therefore not another story of 'bringing the object back' from the periphery, as La Pérouse's charts did to the 'centres of calculation' in France; instead it provides a case study of local, everyday interactions and encounters with an image that affects users' own calculations about their trajectory within, and understanding of, civic space.

Second, this paper explores the complex relationship between representing and intervening through an empirical study of practical activity with images. This duality was famously explored by philosopher Ian Hacking in support of a pragmatic realism about scientific entities in the philosophy of science, shifting focus towards 'intervening' to break out of the hermeneutical circle of representation and the hope to 'hook-up with the world' (Hacking, 1983: 140). However, this paper inverts Hacking's move by asking how much intervening is in fact predicated upon representing, and uses an empirical study to examine how representations stage, structure and justify object interventions. The critical question is located in practice: viz., how do iconic or otherwise highly stable representations of scientific objects guide our interactions with those objects?

This is a difficult topic to explore in the social studies of science, as many scientific objects are made visible, representable and interactable through instrumental means. If we want to explore how iconic images of the atom, such as the Bohr model, quantum cloud, or nano-scale spheres, affect how chemists, theoretical physicists or nano-technologists interact with atoms, we ought first to grapple with the complexities of lasers, electron microscopes, or scanning tunneling microscopes.[13] But the Tube Map presents a fascinating case where the mediating technology in question is, effectively, the image itself. Conversations with users reveal that the map is not only an interface to the subway system, but is also metonymically used as an interface to the city as a whole, establishing a virtual space in which the analog urban environment can be explored, constructed, narrated, and understood. Further, we may bypass fruitless discussion of whether or not the represented object is actually 'there' or represented 'accurately'; the city is clearly both tangible and constructed, and in its myriad experiential forms it does not necessarily always 'line up' with its many representations. The question thus changes from *whether* or *how well* the visualization represents the object, to *how the visualization constructs the object for interaction*.

Turning from the philosophy of representation to practices of interaction follows Michael Lynch's (1994: 149) suggestion that if we wish to produce meaningful analyses of images in science, we ought to cease comparing representations with 'reality' and focus our attention on 'what people do when they engage in an activity that makes one or another "representation" perspicuous'. However, it is still important to note the Tube Map's divergence from a classic geographical projection or even from urban experience, if only because this contrast reveals one of the map's most significant and pervasive practices, and its importance for the study

of representation in science: that is, it is through familiarity with this iconic image that topology and topography become intertwined, enmeshed and confused in everyday practices of interaction.[14] As this paper will show, the represented properties of the network, its nodes and corridors, are incorporated into users' *spatial* mapping and wayfinding practices, narratives, and representations as essential properties of London. Comparing the Tube Map with London above-ground, then, is neither due to naïveté about the illustration's 'inaccuracy' when measured up to 'reality', nor to a lack of expertise or understanding about the map's functions and limitations.[15] Rather, the comparison enables the analyst to probe the specific role and power of the iconic image for envisioning and directing interactions with represented objects; and it is precisely this complex relationship between representing and intervening that this paper explores.

Methods

> The subway is a disconnected nether world, and it is intriguing to speculate what means might be used to mesh it into the structure of the whole. … A detailed analysis of the imageability of subway systems, or of transit systems in general, would be both useful and fascinating. (Lynch, 1960: 57, 74)

This paper presents the results of fieldwork conducted in London in the summer of 2004, when I designed a study to probe the effects of the iconic Tube Map on stories, representations, and interactions with London. This study involved three different methods. First, I conducted interviews with staff at London Underground Limited, its larger umbrella group Transport for London (the organization under the Mayor's Office which administers all forms of London transit, from buses to the Tube to the driving tariff in the inner city), and general Tube enthusiasts, complemented with archival research at the London Transport Museum. Through these traditional methods, I aimed to get a sense of the official history and use of the Tube Map, as well as some alternate views of the system, past and present. Second, I explored another class of interactions, which involved asking for directions and distances to places in London, both above ground and underground. I asked questions of pedestrians across the city, such as, 'How far is it to St Paul's?' or 'How do I get to the British Museum?' Alternating between destinations with eponymous Tube stops and places without clear ties to the subway, I aimed to elicit how the map plays a role outside its traditional journey-planner mode for wayfinding, navigation, and calculating urban space and time.

Third, I conducted more than 20 extended sit-down interviews with a variety of Londoners. Each interview began with the request, 'Draw me London', eliciting a variety of rich accounts and pictures of the city. This technique, called 'cognitive mapping', was first introduced by Kevin Lynch in his now-classic text in urban studies, *The Image of the City* (1960), in which the urban planner asked subjects in Jersey City, Boston, and Los Angeles to draw their city for him to get a sense of what he called 'the image of the city'.[16] Cognitive mapping has since enjoyed popularity in urban planning, geographical information systems design, and cognitive

psychology research into 'mental maps'.[17] However, while this study follows Lynch's (1960: 57, 74) suggestion that the 'disconnected nether world' of the subway's influence on a city's image be explored, I am not interested here in how best to design a city, or whether or not people actually hold a mental map of London in their heads that more or less adequately corresponds to the cityscape. Rather, I am interested in cognitive mapping as a practical activity that brings at least three methodological benefits to Science and Technology Studies (STS). First, it presents a fruitful qualitative method of study: asking people to draw an object that they work with produces not only remarkable and unique images, but also rich stories about the images as they evolve and develop under their pens. Here, understanding image-making as an active process is as important as looking at the final product: sometimes *how* informants drew London was just as important as *what* they drew. Second, the technique focuses on what Lynch (1960: 9) calls the 'imageability' of the city: 'that quality in a physical object which gives it a high probability of evoking a strong image in any given observer'. To avoid essentialism, this might alternatively be read as tracing the *representations* or *instrumental experiences* of a physical object that give it a high probability of evoking a strong image in any given observer. Third, cognitive mapping may present STS with an alternative, literal way of doing epistemography, which Peter Dear (2001) identifies as the main task of Science Studies: a method of describing – or in this case, inscribing – epistemological themes or frameworks in historical and cultural situations. Asking people to draw an object is a powerful way to elicit stories about what they know about that object, presenting the possibility of accessing the effects of disciplinary education, theory-laden observation and representation, and the everyday gestalt switches between representations and objects.

In these three kinds of interactions, the Tube Map clearly influenced representations of the city of London, both imagistic and narrative: it also enabled interventions or interactions with the city, both above- and belowground, and provided a way to distinguish normalcy from distortion, user expertise from resistance.[18] This paper will therefore explore these three themes – representing, intervening, and resisting – in order to draw conclusions about the potential influences of the iconic, stable visual language on patterns of representation and interaction in science.

Practices of Representing

> 'If I asked you to draw London, what would you draw?' 'The Tube Map!' (Interview 4)
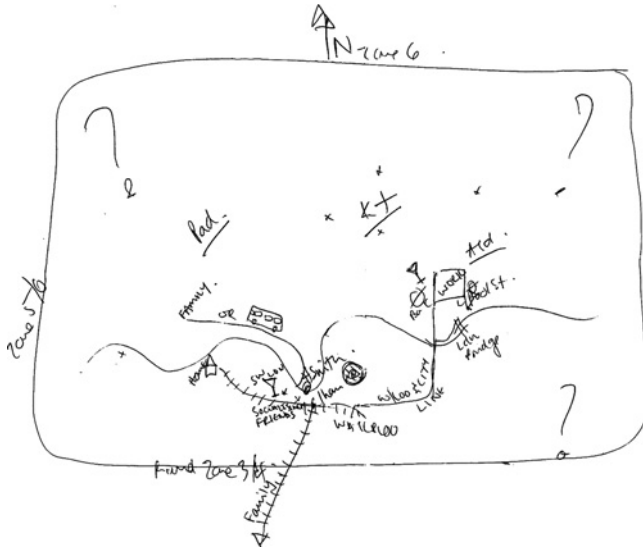
> 'It's the Tube Map. I'm drawing the Tube Map!' (Interview, Peter Wilson)

'It's on the Tube Map, therefore it must be London', exclaimed one interviewee (Interview 3), echoing a common claim that, by showing what is 'on' or 'off' the map, the Tube Map defines what is and what isn't London. This same respondent was keen to discuss how she chose an expensive flat

over a cheaper one because it was close to a Tube station – not because she used the subway to commute, but because her friends would be more likely to visit if she were 'on the map'. This association between station names and London locations runs so deep that whole neighborhoods, such as Queensbury, gain their identities from the naming of a local station: Turnham Green even shifted location from the site of its namesake park to the area around the eponymous station a few miles down the road. It also has political implications, as many of the poorest areas of the city in the south-east do not have underground stops: several of my respondents noted that this makes these neighborhoods even more disadvantaged, as being 'off the map' divorces them from civic culture and political discourse.

However, the definition of what constitutes London is not derived from the physical structural elements of the subway network, but rather from the structural elements of its famous map. This influence goes beyond the station names, which link the analog city to its virtual representation, like geographical Lacanian 'anchor points'.[19] When I asked her to draw me London, one respondent began by tracing a rectangle on her paper, declaring, 'This is the Tube Map, the big one that they have on the walls in the stations' (Interview 9; see Figure 2). Most respondents did not directly articulate the Tube Map's influence on their ideas of the city's boundaries, but the majority chose to draw only central London: Zones 1 and 2 as depicted on the inset maps in the subway cars, centered on the junction between the Northern Line and the Central Line instead of around their own neighborhoods, or even traditional centers of civic power, such as the City, the Walls or Gates, or the Parliament buildings.

FIGURE 3
Tube lines as structure: London as *x/y* axis of the Northern and Central lines (Interview 14).
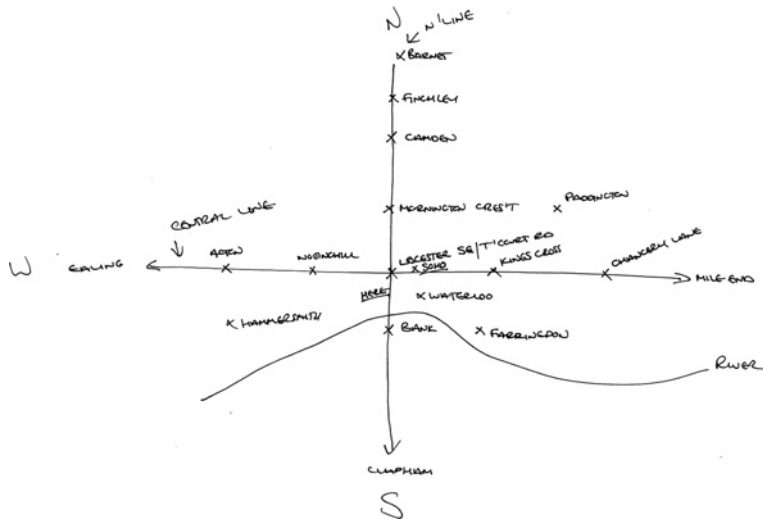
Many respondents articulated the River Thames as the 'backbone' of the city, and set about inscribing the river into their maps. Yet, without exception, they expressed considerable confusion about 'how the river actually goes', pens pausing or tracing a variety of curved lines over the paper. 'I know it [the Thames] does some funny stuff down here ... ', claimed one long-time Londoner (Interview 6). After tracing the river upon their pages, most were unsatisfied, dismissing the squiggle with a comment like, 'This is the wrong scale' (Interview 2). It is not insignificant that the river Thames is the only above-ground feature pictured on the Tube Map, but while Londoners in early user-surveys insisted it remain on the map, its abstracted form has changed shape even over the past few years. Thus the Tube Map's abstract and geometric pattern for the Thames informed mappers that it was 'there' and essential, but even 'walking the river' along the South Bank's popular new pedestrian passage was not enough to provide them with an alternative view of 'how it actually goes'.

The map also lends an underlying axis or structure to the city through the most familiar Tube lines: the Central, Northern, Piccadilly, and Circle Lines. In an interesting example, one respondent who had lived in London for 3 years stated outright, 'I think of it [London], surprisingly enough, as a grid'. He then proceeded to draw an *x/y* axis on his paper, labeling it with station names, from Ealing to Mile End and Barnet to Clapham (Figure 3). When I asked him where the Central Line was on his map, he pointed to the *x* axis: 'And this [pointing at *y* axis], this is the Northern Line.' He spoke about how he judged the position of other London locations with reference to this grid, a practice he demonstrated later, when I asked him to place Paddington Station and the River Thames on his map. This technique also translated into his above-ground interactions: he described how

FIGURE 4
London as distinct localities (Interview 11).

he remained aware of the location of Tottenham Court Road Station (the intersection of *x* and *y*) when moving through the city, so that he would 'know where I am at all times' (Interview 14).

While this interviewee thought of London as a grid, another claimed, 'I think of London as … lots of little centres stuck together … it's something I think about the way the city fits together' (Interview 2). This was not an uncommon way to talk about London, as a collection of disparate and distinct localities. One respondent even drew London as round, open circles, scattered about the page, including little sketches of what one might do or see above ground at any given place: a boat at Greenwich, for example, or a sun-tanning figure at Hampstead Heath (Interview 11; Figure 4). On the one hand, this image of London is an artifact of the city's popular history, a story of a growing metropolis that subsumed or cobbled together a number of small villages. The city does not have a single 'downtown', and different neighborhoods cultivate particular personalities, attract particular clientele and types of residents, and maintain their own festivals or markets. But it is a view of the city that is supported and maintained by the Tube Map, with echoes of the subway experience in general: localities become 'stops' on the map; spaces to surface from the warp of the underground and encounter the above-ground locality. Most of my interviewees described this experience of the city as a matter of not knowing where anything is: one occasional London visitor sighed, 'I have no idea where anything is … I remember spending some time in Trafalgar Square once, but I don't know where that is' (Interview 6).[20] However, another long-time

FIGURE 5
Tracing the Northern Line upwards, placing stops along its path (Interview 19).
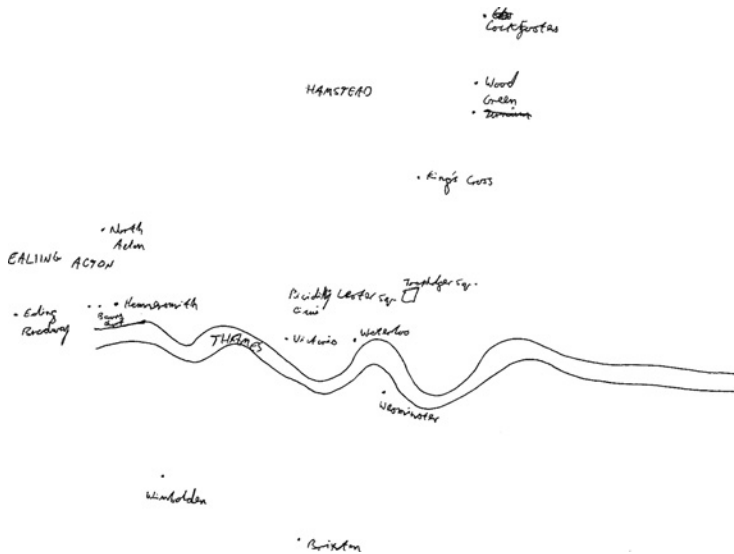
resident let go of above-ground geography entirely in her approach to sub-way travel: 'There's no north, south, east, west down there, there's just Tube lines. All you're aware of is destination: direction isn't relevant' (Interview 1). Still another heavy subway commuter changed his approach to the city in order to combat this mentality: 'I had a sense of dots, I did-n't know where they were. That was a problem for me, so I stopped using [the Tube]. Now they are where I thought they were' (Interview 15).

This latter informant understood London by privileging above-ground geography over 'dots' on the Tube Map, but for many others, the essential elements to understanding the city were the colored lines between these station dots:

> [While drawing,] I just see lots of blue and brown and yellow lines, but to think where everything is [is impossible]. … [Why?] Because of the Underground Map. Because that's how I know London. I can't even show you where Piccadilly Circus is, I'd just get on the Piccadilly Line and get off there or at Heathrow [the end of the line]. (Interview 7)

These lines were sometimes drawn onto the map, but were usually traced with a finger in order to place a locality on their map. The artifacts of this process remain inscribed in their drawings, such as Figure 5, in which the respondent's pen followed the Northern Line (including its branch north of King's Cross) without actually tracing the line, but rather placing station names along this well-traveled route. I also asked my interviewees to place King's Cross and Paddington Station on their maps: the majority placed King's Cross just north of center, and followed the straight line of the Circle Line out to the left, placing Paddington at a right angle to King's Cross and

the Central Line. This is consistent with Paddington's placement on the Tube Map, where the western side of the city is heavily distorted. If my informants had been heavily influenced by driving, riding buses, or looking at 'geographical' projections of the city, they might instead have placed Paddington to the south-west of King's Cross, not level with it.[21]

The placement exercise echoed a common task that Londoners perform in and about their city, a task articulated by one informant invoking an early-modern map-makers' convention, with the phrase, 'Here be dragons'. As the Tube Map defines what is and what isn't London, it also provides a framework for anticipation: places that are familiar only from their stop on the map give a sense of what one ought to find should one go there, while spaces not colonized by station dots or Tube lines present uncharted and perhaps dangerous territory. This 'here be dragons' approach is well illustrated in Figure 1, where large question marks appear on parts of London about which the map-maker has little knowledge aside from the fact that they are on the Tube Map. Wandering too far away from the familiar Underground Roundel, one might still be 'on the map', but somehow disconnected or located in a magical, uncharted space.

Practices of Intervening

> I probably know London better by Tube than I do above ground, because when I'm walking without a map and then I hit a Tube stop, then I know where I am. So I sort of live in an underground world. (Interview 18)

Moving from representation to interaction, respondents reconciled the virtual space of the map with the analog space of the city in their navigational experiences and practices. Several common methods and stories emerged when they spoke of the practical task of getting from point A to point B.[22] In these stories, the map is not only an object to think with (Turkle, 2007) or an object connected with a centre of calculation (Latour, 1987), it also provides, like personal stereos in the city, a 'technologized site of experience' (Bull, 2000: 157): a virtual space in which experiences of the city are lived and interpreted.

One way in which the virtual representation bled into the analog experience of the city is through effects on the sense of urban space and time. The effects of 'railroad space and railroad time' have been well discussed by Schivelbusch (1986), and Hadlaw (2003) even goes so far as to discuss the London Underground Map itself as a manifesto of modernist space and time.[23] These historical and theoretical approaches are here complemented by an inquiry based in practice, in which the effects of this modern representation of space and time are clearly and keenly experienced when navigating, explaining, and wayfinding in the city.

One such effect is in the computation of time and distance in London, whether above ground or underground. When calculating a journey, the two most common 'algorithms' I heard from Londoners were either '3 minutes per stop, 5 minutes to change' or '5 minutes per stop'. Another

FIGURE 6
The Northern Line drawn onto the above-ground in its imagined location (Interview 6).
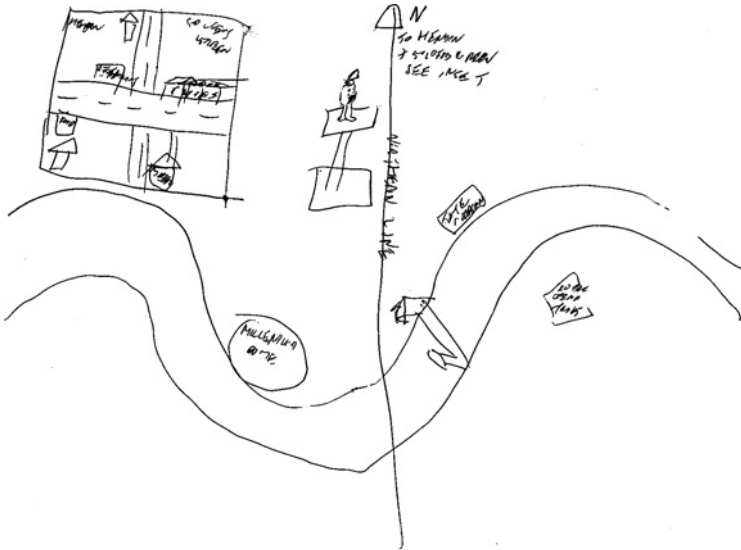
approach was more holistic, based on approximations of larger units of space, such as zones or inches across the map. Proponents of such an approach were likely to say something like, 'that will take you 20 minutes'. When pushed to explain this calculation outside of a direction-giving interaction, one interviewee claimed, 'It's [timing] a very intuitive thing and it's not consistent. I don't have a mathematical formula' (Interview 18), while another stated, ' … the only way I can tell how far things are is the number of stops or what zone they're in; it's my only reference, really' (Interview 6). Interestingly, these distance measurements were often the same regardless of whether the interviewee was approached above or below ground. Above-ground direction givers were just as likely to answer a question such as, 'How far is it to St Paul's?' with 'Five stops', or an equivalent 'Fifteen minutes': only after a puzzled look from the questioner were they likely to qualify this statement with, 'by Tube'.[24]

Interviewees also reconciled their above- and below-ground experience of the city by correcting the Underground Map when they knew from personal experience that it was in error. Many of them performed a pinching gesture at the map, attempting to squish stops together that they knew from urban experience were close-by above-ground: Queensway and Bayswater, and Leicester Square and Covent Garden were consistently subject to such squishing gestures, whereas Monument and Bank were spread apart with an opposing gesture to indicate that they were not as close together as they appeared on the map. Thus the above-ground can be used to correct the Underground Map, which in these cases was held accountable to above-ground experience of space in spite of its own proclaimed a-geographicity.

Yet the above-ground experience was not complete without reference to the underground. One of my mappers, in the middle of drawing an exclusively above-ground map, suddenly exclaimed, 'I gotta have the Northern Line [on my map] but I don't know where it comes from!' (Interview 6). He thus drew it in the straight north–south style of the Tube Map, running just east of Trafalgar Square and crossing the river (Figure 6). Others sometimes placed station markers in the middle of rich above-ground illustrations of their neighbourhoods or work areas alongside local restaurants, banks, or homes, and some even traced a subway line or the imagined trajectory of their underground commute onto their maps. Thus the underground bled into the above-ground in their representations of London.

Turning to street-level interactions with London, the story would not be complete without some discussion of the A-to-Z (the street map book published for more than 100 years by the London Geographical Society), which can be purchased pocket-sized, large map-book style, or for mobile devices. Most Londoners speak of the A-to-Z as crucial for getting around London, and rumor has it that even taxi drivers, London's most expert wayfinders, are lost without it. Examined from the point of view of representational fidelity or even ownership statistics, the A-to-Z would seem to present a challenge to a story of the Tube Map as key to making sense of London. However, from the point of view of practice, it quickly becomes clear that the two are complementary. In spite of many possible scripts for using a city map, I witnessed one Londoner after another perform a back-and-forth flip between the close-up street maps inside the book, and the Tube Map printed on the back cover. The two pieces of the puzzle were linked through station names, the only above-ground Tube presence on the street maps. My informants would usually thumb the index for a location, flip to that page to see the above-ground map, and then locate the closest Tube stations on the page. From there, they would turn to the back of the book to place that piece of London 'on the map' – the Tube Map, that is. The reverse practice, beginning with a station on the Tube Map and finding its location on the street map, was also extremely common. That is, the Tube Map provides the framework into which pieces of the street map are inserted and adjusted, like pieces in a jigsaw puzzle. A London Underground employee summed up the situation based on research conducted after an advertising campaign: 'What we found was people use the Tube Map more than the A-to-Z, even if they're not using the Tube. They'll think, 'I can walk from Gloucester Road to South Kensington' … stations that look close together on the Tube Map, but which the A-to-Z will show as a long walk apart'.[25]

The Tube Map is also entrenched in both direction-giving and wayfinding in the 'analog' city above ground. A particularly rich example comes from an interaction with a clerk at a store in Covent Garden:

> **J.V.:** Excuse me, I'm a little turned around. How do I get to Tottenham Court? (*Presents her London A-to-Z*)

> **Clerk:** (*Looks at the back of the A-to-Z, at the Tube Map*): Well, you won't want to take the Tube from here because you'll have to change lines …

J.V.: (*Pointing to A-to-Z*): I think Covent Garden is on page 14 …

Clerk: (*opens the book and consults page 14*): Okay, come with me to the door and I'll point you on your way. (*Goes to doorway, R follows. He points.*) Okay walk out here and down this street to Covent Garden Tube Station, the Tube Station, and take a left. Walk down that street until you get to Leicester Square Tube station, you'll come to the Tube, then go right, up that street and you'll come to Tottenham Court Road Tube Station at the top of the road and there you are.

J.V.: You mean up Charing Cross Road?

Clerk: Yes. Go left at the Tube, right at the Tube, and there you are.[26]

It is interesting to note that the clerk assumed I was asking for Tottenham Court Road Station, not simply the street, which I would have encountered before the station; he also resisted my references to the above-ground, such as Charing Cross Road, or even the suggestion to look inside the A-to-Z. Further, the Tube here is playing the role of landmark, with stations acting as the means by which people can judge their location and their route. Interviewees often spoke of the Tube station as 'a meeting place, a reference point, even if you're on foot' (Interview 2), and of the disorientation of turning a corner and running into a station that you didn't expect to see, and then realizing that you're in a different part of the map than you had thought. But most fascinating is the route the clerk directed me to follow. Instead of choosing a direct path between the two points, which would lead a tourist through the charming streets and shops of lower Soho, he had me walk the lines of the Tube above ground: tracing out the Piccadilly, then the Northern lines to get to Tottenham Court Road. Thus the imagined, virtual lines of the underground map linked the above-ground station points in routes that made sense, regardless of their fidelity to any train lines below.

Practices of Resistance

> Well really, the only map of London there is, is the Tube Map. (Interview 13)

The majority of my informants made a point of mentioning that the Tube Map is a distortion. It is common knowledge in London that the map's strange geography, expanding the centre of the city and contracting the suburbs in towards the center, does not employ any standard geographical projection to make sense of the disorder above ground.[27] Ironically, however, respondents came to identify the Tube Map holistically as a 'normal' image of London, with the above-ground portrayal constituting the distortion. One of them articulated this switch clearly: 'Something I've always wanted to do is take a map of London and draw out where the Tube lines actually go. It's such a familiar shape and map, it'd be like stretching it over a balloon' (Interview 2). She thus identified the above-ground cityscape as distorted, judging its geographical projection against the standard of the Underground Map. As another interviewee simply stated, 'The Tube Map, you know it's wrong but you know *how* it's wrong' (Interview 13).

My informants exhibited a grotesque fascination with the movement
between the above-ground and the underground, watching the familiar
shapes become distorted. For example, the Piccadilly Line administration
was puzzled by the success of London Marketing's unique poster, 'Above
Ground: A GlobalVision Perspective' (Figure 7), which draws the blue line
of the subway meandering through a partial above-ground view of London,
complete with landmarks. The Real Tube Map, produced by Sam Rich
and posted on the London Underground site, gets thousands of hits, as do
other home-made graphics which attempt to place the lines of the subway
on a satellite image of the city.[28] This kind of disorientation or sense of not
knowing 'where the stops are' is reflected in the popular BBC radio show,
Mornington Crescent, which takes an absurdist approach to the map, ask-
ing contestants to rattle off station names based on association or stream of
consciousness.[29]

Moving away from the map towards the surface, coming to know '*how
it's wrong*', is not just an exercise in cognitive dissonance; it constitutes an
important step towards establishing expertise in London. The urban legend
of the tourist who takes the Tube from Leicester Square to Piccadilly
Circus was often repeated to illustrate what you wouldn't know if you had
just arrived in London: the tacit skills of city navigation that come with

time and experience. Another cognitive mapper began his response to 'Draw me London' with: 'I'm thinking of the subway map first of all, but that isn't a very useful map for the above-ground … so I'm putting myself on street corners that I know in my mind and I'm thinking how would I get there from here' (Interview 16), revealing that he was expert enough to know when and where it was appropriate to use the Tube Map. Some 'users' of London spoke of 'weaning their way off' the map either purposefully or unintentionally. During a Tube strike, one interviewee was surprised to find that she lived closer to her workplace than she had thought, and that it was both easy and enjoyable to walk home from work; she thus made a habit of walking from then on. Thus a clear hierarchy of users emerged, in which exclusive reliance on the Tube Map to get around London demonstrated inexperience with the city, while the more experienced spoke of a cumulative above-ground competency and displayed an ability to use the Tube Map selectively as a tool.[30] Such advanced users even revealed an anthropomorphic familiarity with the Underground, speaking of individual lines' 'personalities'. However, even those who had grown up in London still used the 'Here be dragons' technique to identify places they had not visited: this held true for Londoners who avoided using the Underground system as well, preferring instead to bike or walk. The pervasive nature of such practices supports Sally Wyatt's (2003: 76) claim that both active and passive non-use of a technological system may be partial and not necessarily holistic.

Although familiarity with the above-ground cityscape may demonstrate expertise, pushed too far it can be seen as an aberration. For example, a cognitive psychologist at a British university insists that the hallowed design principles of the Tube Map are counterintuitive for human psychological hardwiring (Roberts, 2007). According to his extensive research on the perception of different geometries, as well as his own well-honed geographical sensibilities, the map's characteristic angles and shapes make the city more, not less, difficult to understand. A Tube enthusiast himself, he set about building a new Tube Map to conform to alternative guidelines generated from his studies, painstakingly constructing it from pieces of the original using Microsoft Paint. But when he showed the result (Figure 8) to an official at London Underground Limited, the response was telling:

> You should entitle it The Devil's Map. It satanically undermines all that is good, clean, pure about Beck's sacred qabbalistic [sic] map. Seriously, though, I think it's psychologically very disturbing to see London messed around in this way.[31]

This is not an uncommon response to Dr. Roberts' alternate map. Instead of finding it easier to understand, the majority of viewers consider his map incomprehensible or display the same fascination they do for the above-mentioned alternative views: few are converts to his way of seeing the city. As he points out, 'The real irony is that I've messed about with London much less than the standard Underground map does!'[32] But, as Latour (1990: 51) suggests, abstracted inscriptions may inspire stronger belief
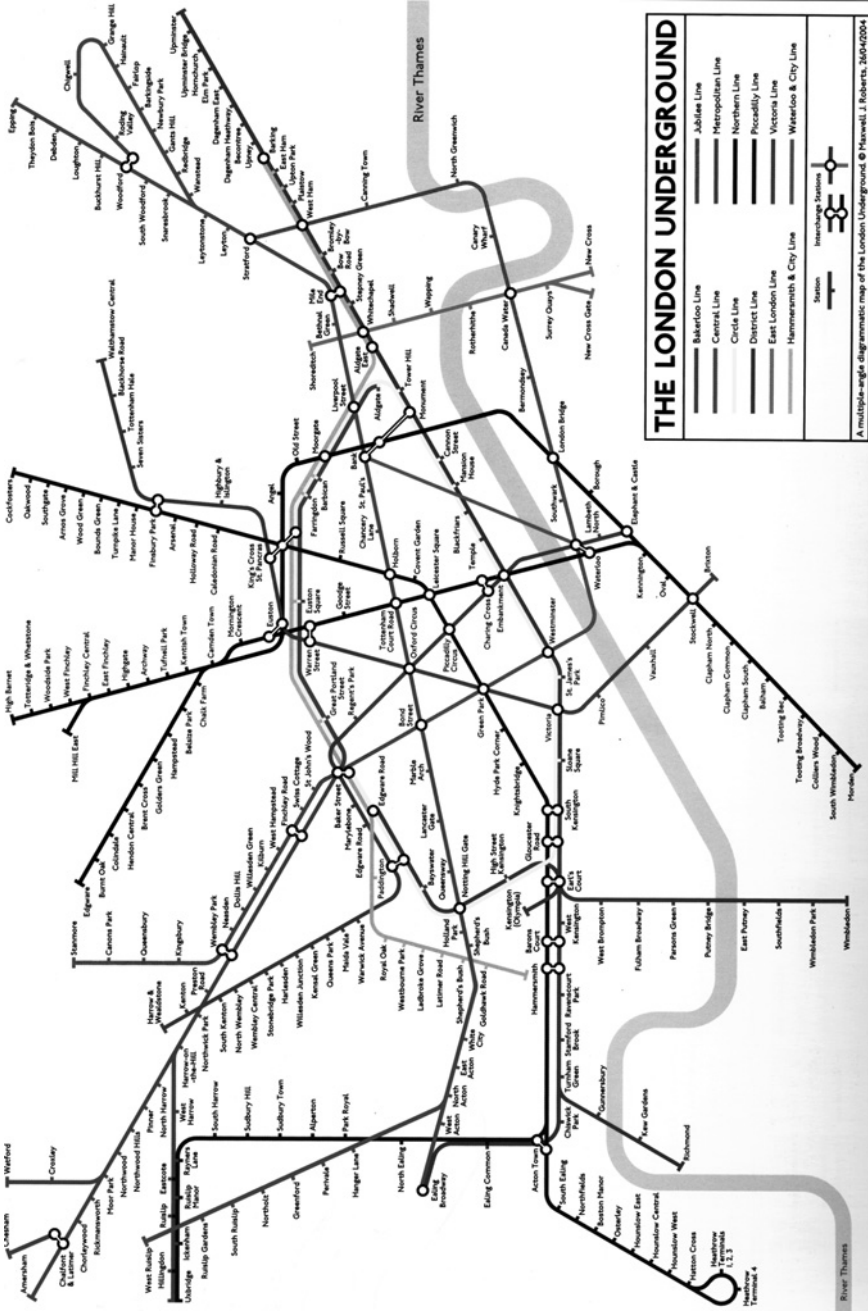
than 'any contrary indications from the senses', or even from experience. Perhaps the final irony is that the standard, abstracted Underground map constitutes such an important way of understanding London that it is no longer seen as a distortion: it has instead become the measuring stick by which normalcy, expertise, and resistance in picturing and interacting with the city are judged.

Conclusions

When we consider the map as a visual technology in action,[33] mediating between the user and the complex socio-technological system of the city, the effects of representing on intervening become more easily discernible. A stable, iconic representation such as the Tube Map may convey a general sense of structure, establish points of interaction, and enable further representations and narratives about the object. It can act as a reference point for practices of navigation and wayfinding, affording judgments of normalcy and degrees of expertise or resistance. It may also, through its mapping of topological connections, be read not only as a subway map but as a useful way of representing the city in general: an object it does not pretend to represent. The Tube Map thus becomes something of a graphical user interface to the city, presenting and concealing opportunities for engagement, and making sense of the city to its users.

This paper began by claiming a tie between the Underground map and iconic or stable imagery in science, and some final comments on that analogy are in order. First of all, the above discussion suggests that we should expect to see some correlation between the properties of representation, intervention, and resistance, not only with regard to subway maps, but in scientific representations as well. It is important to note that the map is not the *only* technology for experiencing a city: urban residents may walk, bike, bus, or have many other mediated experiences. Similarly, scientists may look through a variety of microscopes or scanning devices, or perform a number of technologically mediated experiments on a represented object. If pushed, they too refer to the representation as a kind of shorthand, or unpack the technology of representation ('this isn't really what an atom "looks like"'). But recalling that even seasoned users have strong ties to the Tube Map, using it to put London together and put themselves 'on the map', the present study suggests that even expert users may maintain general reference to an iconic image, as a way to structure explanations or to extrapolate to the unknown.[34] As such, methods for understanding varying uses of stabilized representations might be useful for exploring how citizens and scientists use visual icons as map-like interfaces to their objects of interest.

Further, when following an immutable mobile from its site of production to its site of mass use, we notice that the mutability is not necessarily in the image's physical form or delineation, as Adrian Johns has famously critiqued.[35] Rather, the mutability lies in the *representational referent*, the image's indexicality, which changes in an appropriated (but still expert) con-

text of use. In what we might call a 'visual language game', the visual language of the map is sensically interpreted such that the image comes to represent not just the subway network, but also London itself.[36] Extending this Wittgensteinian approach, we might note that the gestalt switch between seeing the map as the subway network and seeing it as London is both effected by and has tangible effects upon narratives, representations, and practices of civic navigation. This is not a naïve gestalt switch, an example of reading a duck as a rabbit by accident or due to misunderstanding, but rather a necessary navigation between object and representation, subway, and city, with implications for object interactions and interpretations. As analysts of science, we ought especially to look out for the locations of this representational turn and its subsequent effects on object interactions in scientific practice. For example, just as Dumit (2003) considers the effects of positron emission tomography (PET) scans on a patient's sense of identity, we can identify a location of practical scientific activity in which it makes sense to say of an image like a brain scan: 'Now I see it as distributed brain activity; now I see it as a depressed person: We ought to be attuned to similarly sensical expressions that allow easy gestalt movement between representation and object, virtual and analog environment.

This study also demonstrates that modes of representation should be treated analytically as inseparable from a community's interactions with (and within) a technological system: that is, *the study of representations in interaction is critical to the study of technological systems in action*. Such representations are more than passive illustrations or things-to-think-with, they are also *things-to-act-with* – and interact with – in subsequent access of the represented object. A departure from questions of accuracy, even if judged 'in terms of pragmatic utility' (Gieryn, 1999: 11), enables the analyst to move towards questions of how different communities of users define and draw their objects of study, with what effects on or relationships to their practice. As such, we are challenged to examine the representation as distinct from a discussion of ontology, topology, utility, or mimetic fidelity – against which the Tube Map would surely fail as an 'accurate' representation of London above-ground – to analyze the concrete ways in which representational organization enables narratives of movement and manipulation and, most important, to locate the boundaries and points of interaction *for particular communities of users.*

In 2003, London Underground Limited launched a widespread advertising campaign aimed to establish a strong connection between the subway system and London. The memorable advertisements featured Londoners enjoying activities associated with particular parts of the city made accessible by Tube, but in incongruous locations: a university professor giving a lecture dressed in Portobello Road carnival gear (I ♡ Notting Hill), or a typist in an office surrounded by exotic flowers (I ♡ Kew Gardens). At the end of the advertisement, a split-second scene of the arrival of a subway train replaces the You and the heart in the phrase 'You ♡ London' with the word We and the Underground roundel respectively, implying that the Underground comprises the essential fabric of the city, tying its disparate

locations together and making the distant present. Londoners responded positively to the 'Love London' advertisements, but a post-advertisement survey was puzzled to find that the majority of those surveyed did not know what the advertisements were for. For them, the advertisements simply stated the obvious. The same survey also found that Londoners overwhelmingly responded that they 'Could not imagine London without the Underground', ranking the statement between 7.1 and 8 points out of 10 regardless of whether they used the Tube or not.[37] This paper may provide some clues to understanding why such results are not surprising in the least. The advertisement was beaten to the punch by a technology as essential to forging the intimate connection between the Tube and the city of London as the physical, steel lines of the subway itself: the London Underground Map.

Notes

1. See Moss (1996) for London Underground Limited (LUL) placement regulations in the train and on the platform, and Rattner (2003: 39–40) for recent Journey Planner statistics.
2. It is, unfortunately, beyond the scope of this paper to pursue the historical development of the Tube Map. Interested readers are referred to Ken Garland's (1994) definitive work on Beck; also Leboff & Demuth (1999), Leboff (1985), and Roberts (2005); on general Underground history, see Halliday (2001), and Day & Reed (2001). On current design principles, see the London Underground Limited's standards document (1993), wherein the company's view on the image is stated: 'the diagram itself is termed a "Journey planner" as it is not a literal representation of distance and geography, therefore it should not be called a map' (p. 4).
3. Edward Tufte is a proponent of the Tube Map's simple but effective design strategy (see his website at <www.edwardtufte.com>); it is also taught in a popular Human–Computer Interaction conference class on designing graphical interfaces (see Mullet & Sano, 1995).
4. The seeds for this project were sown several years ago when, in an interminable holding pattern over Heathrow Airport, the clouds below my plane parted, and I saw London from the air for the first time. It took me a long time to figure out what I was seeing, and I was disconcerted by my extreme disorientation caused by this sudden, holistic view of the city above. This mimics the visitor's disorienting experience with the ceramic model of Paris in the Samaritaine in Latour & Hermant's, *Paris: Ville Invisible*

(1998) – the title a play on Calvino's (1974) *Invisible Cities*, the story of Marco Polo relating the world to the great Khan. Seeing, representing, and narrating the city are key themes in the current discussion.

5. The map as site of wayfinding interactions is explored in Brown & Laurier (2005). I thank Barry Brown for making a manuscript available before its publication.

6. Interestingly, the only alternative maps of the subway network in public circulation are independently produced by travel guide companies, who, restricted from printing London Underground intellectual property for independent financial gain, are forced to come up with their own images. A comparative study of these alternate views by Roberts (2005) is underway, but it would be interesting to explore tourists' interactions with the system based on these guidebook images.

7. The literature on the meaning of maps is extensive. Important critical approaches to the material from the science studies perspective are Cosgrove (1984) on symbolic landscapes, Harley (1988) on Foucauldian themes of knowledge and power, Turnbull (1996) on knowledge spaces, and Wood's (1992) excellent introduction to maps in general. David Turnbull (2006) has also, very recently, written about the Tube Map, and I thank him for sharing this paper with me during the final stages of my project.

8. King's College London's 'Work, Interaction and Technology' group has studied the skills, 'situated actions' and material object interactions involved in operating a Tube line (Luff & Heath, 2000; Hindmarsh & Heath, 2000; Heath & Hindmarsh, 2000).

9. Aibar & Bijker (1997) discuss Barcelona as a socio-technical artifact of the technology of town planning; Hommels (2005) introduces city-planning and reconstruction as a theme for STS applications to urban studies; Latour (1996) discusses a city's construction of a subway system from the point of view of the subway train, and other implicated actors.

10. This paper will continue to use the term 'users', derived from Human–Computer Interaction studies, to refer to people who interact with London, as well as users of the London Underground network. While there is significant overlap between these two categories, they are not identical: many Londoners resist using the Tube or take alternative forms of transit, but those I spoke with still resorted to the Tube Map when wayfinding in London. An excellent collection of critical scholarship on 'users' as a category is included in Pinch & Oudshoorn (2003).

11. Interview, R. Smith, London Underground Limited, 21 June 2004.

12. The original source on immutable mobiles is Latour (1990 [1986]).

13. It is therefore not surprising that Hacking (1983, ch. 11) spends considerable time deconstructing the constructivist claims about the microscope to show that we *can* have direct access to the natural world even through a mediating technology. See Dennis (1989) for an excellent constructivist discussion of representation and instrumentality with regard to microscopes.

14. For a particularly illustrative early discussion of topology, the non-Euclidean 'social space' of relationships between components in an actor-network, see Mol & Law (1994).

15. This is Law and Lodge's (1984) assumption. They write: 'Clearly this map [the Tube Map] is not a proper representation of the London Underground System *except for certain purposes*. It has, in fact, been specifically designed with one major purpose in mind: to allow travelers to plan routes through the system with the greatest possible efficiency … And when the system is running properly, this reading of the map is right' (62–63). However, this paper will show that there are other purposes to which the map is routinely put.

16. Note that the researcher did *not* ask their subjects to draw a *map* of London: the question was *always* 'Draw me London.' The result was, however, always a 'cognitive map' approach to illustrating the city.

17. For current trends in cognitive mapping in psychology, see Freundschuh & Kitchin (1999) and Kitchin & Freundschuh (2000). On cognitive maps and geographical information systems (GIS), see Freundschuh & Egenhofer (1997) and Brown & Perry (2002).

18. It is worth noting here that this study is not ethnographic. While I observed others and participated in reading the map and riding the Tube, it would be impossible to try to

witness above-ground interactions in which the conventions of the Tube Map confront the activity of navigating above ground: people cannot walk through buildings, and personal disorientation is rarely expressed overtly or advertised publicly in a large city. Thus, this project focused on representations and narratives about interactions, the ways in which people talked about and drew the city. It is here that the rich stories about interacting with London came out, as well as tracing the lines of the Underground Map in their stories and drawings, and here where I believe we might best access the ways in which the virtual and analog spaces of map and city are breached and reconciled.

19. I am grateful to Rachel Prentice for alerting me to this connection.

20. He may also have been confused because Trafalgar Square, although it is a London landmark, has no eponymous Tube Station: it is framed, instead, by Charing Cross and Leicester Square. It is worth noting that some respondents attempted the interesting trick of showing me where above-ground landmarks 'were' on the Tube Map, such as Green Park, Hyde Park, or Trafalgar Square. They did so by filling in the blank spaces between the lines of the map, but never colored outside the lines.

21. Interviewees usually chose the Northern Line as the city's meridian, labeling 'north' and 'south' at its extremes, and placing east and west on either side of the Central Line like the cardinal points of a compass. While this geometricity conforms to the right angles of the Tube Map, it does not reflect the positioning of the city more generally.

22. Perhaps I should state the obvious: people use the Tube Map to use the subway. A major site of interactivity occurs in front of the official maps placed in the stations, on the subway platforms, or inside the carriages, where people stand in front of the map alone or in groups, peer at it, argue over the best way to go, point at it, and trace pathways across the city, counting stops and calculating their exchanges. Viewing these interactions, an official London Underground study called the Journey Planner 'the definitive reference document' (London Underground Limited, 1997). While these interactions are interesting, it was impossible to get anyone to explain to me what they were doing: using the map is so assumed and so widespread that passengers gave me incomprehensible stares (or dirty looks) when I asked for clarification. Further, it was not entirely clear what asking for such information could mean: this is not, after all, a study of people using the map for the purposes for which it was constructed, but rather of using or re-appropriating the map to explain, narrate, and otherwise represent an object for which it was not intended. With regard to getting people to verbalize the mental arithmetic they do in front of a map, I found the technique of asking for distances and time estimates more fruitful, that is, asking a fellow traveler how much time they thought a particular journey might take. For a conversation analysis approach to direction-giving interactions, see Psathas (1991).

23. See especially chapter 3 of Schivelbush (1986). Hadlaw (2003: 35) reads the Tube Map as a capitalist depiction of both space and time that is 'orderly, lucid, regular, efficient, and entirely functional'.

24. This recalls Annemarie Mol's (2003) interaction with an atherosclerosis pathologist who similarly qualifies his statement of visual fact with 'Through a microscope'; indeed, we might see the Underground Map as one representation of enacting London, representative of one of London's multiple – and oft-enacted – ontologies.

25. Interview, P. Amlani-Hatcher, London Underground Limited, 21 June 2004.

26. 11 May 2004, 1:15 pm in the Body Shop store at Covent Garden.

27. There is a political history to this choice. Before 1932, the underground lines snaked across a full-sized map of London and its environs, requiring a lot of paper to manage in transit if a traveler wanted to double-check their route. Beck therefore chose to inflate the center and conflate the periphery in order to fit all the stations on a single, manageable map. His design was turned down when presented to the management, but taken up a year later when the individual, privately owned Underground lines merged into a new, single, public company. Along with ownership of the train lines came ownership of the land the lines were built on (outside of the city center, that is), and the possibility for property development. To advertise new communities such as Golder's Green as viable neighborhoods for London professionals, Beck's map was ideal: it promoted the new developments by placing them 'on the map', made it seem that these

suburban locations were close to the city center, and encouraged regular use of the Tube in daily commutes. See Garland (1994) and Halliday (2001).

28. Rich's creation is now part of the London Underground official site: <www.tfl.gov.uk/tube/maps/ realunderground/realunderground.html>. (S. Rich, personal correspondence).

29. See the unofficial site of this long-running BBC radio game show at <www.morningtoncrescent.org>. Peter Wilson's TubeGuru system takes advantage of the ties between Tube Map and street map, using the Network Diagram as interface to cross-listings from clubs and restaurants, and the A-to-Z street map, maintaining the integrity of each representation to bring station-focused events to users: see the Tube Guru online at <www.visitlondon.com/tubeguru/>.

30. On such a scale, taxi drivers were often revered, thought to possess an almost magical sense of where things are and how to get there exclusively above ground.

31. Psychologist, personal correspondence.

32. Psychologist, personal correspondence.

33. This visual technology may be a complement to the literary technology for virtual witnessing, uniting citizens in a shared, virtual view of their urban environment much as Boyle's literary technology rallied a shared view of an experiment. See Shapin (1984) on literary technology, and Shapin & Schaffer (1985) on virtual witnessing.

34. While it is beyond the scope of this paper to engage in the structuration debate, it is worth noting that as the icon or the map both enable and restrict classes of object interactions, these may present a kind of technological 'frame', in Bijker's (1995: 191–2) terms, which can 'provide actors with the goals, the ideas, and the tools needed for action. [Frames] guide action and interaction … But at the same time the building up of a technological frame will constrain the freedom of members of the relevant social group.' On structure and action, Gieryn (1992) is particularly helpful.

35. Johns (1998) critiques the immutability of the immutable mobile in his detailed history of piracy in the 17th-century book trade.

36. This, of course, plays off of Wittgenstein's (1958) terminology to suggest a contextually organized environment of activities that establish sensical and non-sensical visualizations in a local setting. Lynch & Law (1999) develop the notion of the 'literary language game' as a method of using a text in the organized practice of an activity.

37. 'Unlocking London' (London Underground Limited, 2004: 22, 35).

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Janet Vertesi is a doctoral candidate in the Science & Technology Studies Department at Cornell University and a 2007 Fellow of the Cornell Society for the Humanities. Her work on representation in scientific practice ranges from case studies in 17th-century lunar mapping, published in *Endeavour* and *Studies in History and Philosophy of Science*, to a forthcoming dissertation on the visual technologies of the Mars Exploration Rover mission. The present paper won the Hacker-Mullins Prize from the American Sociological Association, Science, Knowledge, & Technology Section in 2006.

Address: Department of Science & Technology Studies, Cornell University, 306 Rockefeller Hall, Ithaca, NY 14853, USA; fax: +1 607 255 6044; email: jav38@cornell.edu.