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Amit Prasad

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Entangled Histories and Imaginative Geographies of Technoscientific Innovations

AMIT PRASAD

Department of Sociology, University of Missouri-Columbia, Columbia, MO, USA

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> Ah! 'Factory.' Is the word the same as our *factorerie* ... No Your Majesty. 'Factory' comes from a word that was first used by the Venetians and then by the Portuguese, in Goa. (Amitav Ghosh, *River of Smoke*, 2011, p. 172)

> We are obliged more or less constantly to rethink our notions of frontiers and circuits, to redraw maps that emerge from the problematics we wish to study rather than invent problematics to fit our pre-existent cartographies. (Sanjay Subrahmanyam, *Explorations in Connected History*, 2005, p. 4)

The issues that Vilnius Declaration raises and Ulrike Felt's engagement with them have profound implications within as well as beyond Europe. The role of social sciences and humanities (SSH) in innovation is in the spotlight in many nations. It is being debated even at the level of particular institutions such as my own university. In the USA the House of Representatives Bill HR 4186, which is aimed at enhancing 'investment in innovation through scientific research and development', controversially seeks to cut the National Science Foundation's funding for social and behavioral sciences.[1]

In this article, I briefly draw upon my research to extend the debate on the relationship between SSH and sciences and engineering. Through a dialogic

Correspondence Address: Amit Prasad, Department of Sociology, University of Missouri-Columbia, Columbia MO 65211, USA. Email: prasada@missouri.edu

engagement with the Vilnius Declaration I highlight the significance of mapping connected trails and entangled histories of technoscientific innovations and the crucial role of SSH in uncovering them.[2] I argue that trails of technoscientific innovations commonly cut across national, institutional, and disciplinary boundaries and yet these cross-cutting entanglements often remain invisible because of our imaginative geographies.

Innovation Union: Weaving Together Entangled Histories and Cultures

> Europe will benefit from wise investment in research and innovation and Social Sciences and Humanities are ready to contribute ... Their integration into Horizon 2020 offers a unique opportunity to broaden our understanding of innovation, realigning science with ongoing changes in the ways in which society operates (Vilnius Declaration, 2013).

In her engagement with the Declaration's call to integrate SSH with sciences and engineering, Felt (2013) highlights a multi-layered anxiety that is propelling such efforts at 'imagining Europe's future'. When thinking about Europe's future,

> European policy discourse have been gravitating around a tight articulation of three concerns: (1) a concern for international competitiveness . . . ; (2) a concern for urgency in realizing these innovations as otherwise Europe is imagined to fall behind; and (3) a concern for strong societal support for these innovations' (Felt, 2013).

As Felt (2013) rightly observes, this embodies tensions of combining scientific and societal valuations that cannot be wished away. Indeed, 'understanding of the tensions between societal valuation and scientific evaluation' should be 'at the core of any democratic concern' (Felt, 2013). These two valuations are nevertheless inseparable and inform each other. Highlighting their mutual entanglements requires critical investigation of the role of 'map making as world making' (Felt, 2013).

Maps of various kinds have proliferated in recent years. Some highlight R&D spending across nations, disciplines, and sectors; others define collaborations and excellence through citations indices, and so on. 'These maps serve as orientation devices for researchers and policy makers', yet it is often forgotten that maps 'never simply represent the pre-existing' but also 'produce what will be regarded as reality' (Felt, 2013). Felt provocatively calls for inclusion of 'monsters' in such maps in order to be ready to envision new futures that do not see diversity as obstacles, but rather as resources for technoscientific innovations. She calls for 'systematic fostering of a comparative epistemology' (Felt, 2013).

Here, I explore Felt's concerns by problematizing and thereby extending her call for 'new knowledge relations'. I draw on Said's (1979) argument that 'imaginative geography and history' dramatize 'the distance and difference between what is close' and 'what is far away' (p. 55). 'There is always a measure of the purely arbitrary in the way distinctions between things are seen' and shown in maps (Said, 1979, p. 54). The issue here is not merely the fidelity of 'maps' to reality, because mapmakers, in a significant way, are 'not even trying to be accurate' (Said, 1979, p. 71). Alongside representing 'reality', map-making is also commonly implicated in imprisoning and boxing in map's constitutive elements, e.g. metrics, disciplines, institutions, nations, etc. Not unlike Said's description of Orientalism, these maps often become imperial exercises that hide connected trails and entangled histories of technoscientific innovations.

SSH can show the dialogic, creative, and hierarchical interplay between maps and travels of technoscience. Yet social scientists (and as Said shows, humanists) have been complicit in an imperial role of map-making. So I wish to provide a particular role and a particular analytical and methodological strategy for SSH. Historians and sociologists can highlight entangled histories that otherwise become invisible through 'imaginative geographies' of technoscientific innovations.

My broader concern here is not just limitations of map-making. Rather I would like to argue that techno-cultural flows 'across political [cultural, disciplinary, institutional, national, supra-national, etc.] boundaries . . . even if they . . . [find] specific local expression – enable us to see that what we are dealing with are not separate and comparable, but connected histories' (Subrahmanyam, 1997). I prefer the term entangled instead of connected because 'it better signifies the complex, tenuous, and often invisible folding of ideologies, classificatory schemas, institutions, political economies, cultures and so on from different time periods and across distant geographies, as well as between structured and emergent practices of technoscience' (Prasad, 2014, p. 7).[3] Connected trails are, for example, entangled with imaginative geographies of technoscience.

In the next section, I briefly illustrate my concerns with a few snippets of history from my study of magnetic resonance imaging (MRI) research and development in the USA, Britain, and India.

Imaginative Geographies and (Dis)Connected Trails of MRI

In 1982 N. Lakshmipathy, the then Director of Institute of Nuclear Medicine and Allied Sciences (INMAS), where India's first MRI (built by Siemens) was installed, 'came to know about this new imaging modality, which was not called MRI at that time, when a British scientist showed the in vivo images of human anatomy produced by it during a talk at INMAS' (Prasad, 2014, pp. 80–81). Lakshmipathy also proudly informed me that

> the MRI machine at INMAS 'was not just the first in India but also the first in Asia.' He based his observation on his 1984 meeting in the United States

with a Japanese delegation that was trying to import MRI to Japan. (Prasad, 2014, p. 82)

He thus went westward, to the USA, Britain, and Germany, in his bid to import India's first MRI machine.

In 1974, nearly a decade before Lakshmipathy came to know about MRI, Paul Lauterbur, who along with Peter Mansfield received the Noble Prize for the invention of MRI in 2003, made the first international presentation of his technique for nuclear magnetic resonance (NMR) imaging in Bombay (present-day Mumbai). In a grant application to cover the costs of his visit to India he also sought funds to meet G.N. Ramachandran, who 'was internationally known for his work on X-ray crystallography and had published important papers on image reconstruction techniques for computed tomography' (Prasad, 2014, p. 91).

The radiological community in India was not just unaware of this episode, but also more generally knew little about NMR and imaging research in India, which was not only in frontier areas, but also had a long history. The radiological community in India thus followed, as I show later, commonly used 'maps' of technoscientific innovations that emphasized a West versus non-West (or North versus South) techno-cultural divide. In the process, the radiological community in India rarely utilized available expertise within India.

In another incident around the same time, William Oldendorf, an American scientist, during an NMR imaging (MRI was called NMR imaging then) conference at Winston-Salem in 1981, was lamenting 'the poor showing of the US groups relative to those in the UK'. He explained that such a situation 'was due to excessive numbers of US physicists working in defense to the detriment of medical research' (Bydder 1996, p. 248). Nonetheless, in a span of just two–three years the transnational geography of MRI research and development changed dramatically. John Mallard, who headed MRI research group at Aberdeen, Britain, that was at the forefront in developing crucial features for MRI such as the spin-warp technique, noted, 'by 1984 our team's clinical papers were being rejected by editors and referees because they were no longer "state of the art"' (Mallard, 2003, p. 363).

This shift is particularly striking because Britain, apart from being the center of MRI research in the second half of the 1970s and the early 1980s, also had industry involvement in MRI development. Electrical and Musical Industry (EMI) was among the first in the industry to start MRI-related research (at that time it was also the leader in the development and manufacture of Computed Tomography scanners). The Aberdeen group, through funding from a Japanese company, Asahi, also invested in industrial development of MRI.

In 1981 the MRI division of EMI, which was about to be sold to General Electric (GE) of the USA, was eventually bought by the UK-based General Electric Company (GEC). GEC soon thereafter acquired Picker, an American company based in Ohio, and became Picker International. Donald Longmore, a long-time friend of Lord Arnold Winestock, the owner of GEC, informed me the reason for the American focus: 'GEC had this problem that they didn't have a market in America ... GE [of the US] had it all'. Until August 1984, on the eve of Federal Drug Agency's approval of MRI for clinical use, Picker International had 12 MRI machines placed in clinics in the USA, while GE had only three such placements (Steinberg and Cohen, 1984). GEC's focus exemplified an imaginative geography that resulted in the MRI industry completely moving out of Britain and in further consolidating the dominant position of the USA.[4]

GEC not only made the USA its major focus in relation to marketing, it also did little to utilize available expertise in Britain that had made the UK the center of MRI research in the second half of the 1970s and the early 1980s. William Edelstein, an American, who had a key role in making Aberdeen one of the most important sites for MRI development, wanted a job in Britain and approached GEC. But GEC, as Edelstein informed me, was not interested. Edelstein and Paul Bottomley, an Australian, who worked at Nottingham, Britain, another important center for MRI research, were hired by GE (USA). They played pivotal roles in devising high-field MRI that eventually made GE the market leader in MRI manufacturing in the second half of the 1980s (Prasad, 2014).

These episodes from the history of MRI research and development, at one level, exemplify the 'maps' of technoscientific innovations that, as I show below, were extensively used in the 1980s and 1990s. And yet, at another level, they also highlight entrapment within and thereby further consolidation of the 'imaginative geography' that undergirded these maps (for a more detailed analysis of entangled histories and connected trails of MRI; see Prasad, 2014).

An influential paper starts with the assumption: 'There are two countries, innovating North and non-innovating South' and technological lag between these two regions 'gives rise to trade' (Krugman, 1979, p. 253). In the 1990s economists of technological innovation refined this map, though the North/South dichotomy continued to be used as well. Mapping the R&D expenditure and US patenting activities of 569 firms in the 1980s, Pari Patel presented a triadic structure of 'techno-globalism' encompassing the USA, Europe, and Japan. He also argued that while the firms in the USA and Europe had significant amount of collaboration between themselves, they rarely collaborated with Japan (Patel, 1997).

These 'maps' are based on rigorously collected data-sets. They help us understand the geography of technoscientific innovations in the 1980s and the 1990s. But they are fused with an imaginative geography that boxes in some geographical regions by using certain metrics, e.g. patenting activities. And as such they are also complicit in maintaining the hegemony of techno-cultural dichotomies such as global North and South or West and non-West.

Historians and sociologists as well as economists utilized this imaginative geography. Goonatilake (1984), for example, argued that there was lack of creativity among the scientists in South Asia that was a result of major paradigms of science being developed in the West, with only minor variations of these paradigms occurring in the non-West. There is no a priori way to judge whether a particular technoscientific development will be a major or a minor paradigm, as the early history of Lauterbur's imaging method illustrates (Prasad, 2014). Had it not been for the entangled histories and connected trails, Lauterbur's method would have become a footnote in the history of NMR.

Although they explain some features of transnational geography of technoscientific innovations, the above-mentioned maps fail to explain patterns of non-collaboration, non-utilization of available expertise, etc. within and across nations. They also dramatize 'the difference and distance between what is close' and 'what is far away'. Such dramatization is an artifact of the imaginative geography that undergirds these maps, which nevertheless affect the travels of technoscience and reinforce existing hierarchies. These maps are also silent and blind toward entangled histories and connected trails that cut across commonly accepted geographical boundaries. Excavation of entangled histories and connected trails is thus crucial for reimagining new futures of innovations, particularly in the rapidly shifting transnational geography of technoscience.

Conclusion: Reimagining National/Supra-National Entanglements of Innovation

In her call for 'new kinds of knowledge relations', Felt (2013) argues for the 'creation of new kinds of relations between people engaged in different knowledge generation practices' and 'for a serious engagement with and novel articulations of different kinds of knowledges'. In this spirit, I have emphasized the need for exploration of entangled histories and connected trails. I have argued that maps (and map-making) – which are simultaneously technoscientific and political – need to be creatively and critically imagined in order to excavate entangled technoscientific travels.

Comparative studies allow us to interrogate taken-for-granted categories. 'Comparison offers salutary reminders of the degree to which even the homogenous West is not univocal in its responses to science and technology' (Jasanoff, 1996, 2005, p. 290). Michel Callon and his colleagues offer a somewhat different analytical and methodological strategy. 'A universal (the aggregate collective) obtained through finicky elimination of specificities', in their framework, 'is replaced by a universal (the composed collective) linking singularities that have been rendered visible and audible' (Callon *et al.*, 2011, p. 134). They argue, 'what matters in fact is being interested in what is specific and singular in particular voices in order then to compose them without concealing their existence' (Callon *et al.*, 2011, p. 134).

My concern is similar to these contributions for analyzing histories and geographies of technoscientific innovations. In this article, I offer another analytical and methodological strategy for this purpose – that of entangled histories. Particular individuals express their 'voice' and particular events acquire meaning within networks and processes of circulation. These networks and processes of circulation do not have straightforward, empirically pure visibility or invisibility. Technoscientific travels within such networks and processes of circulations, as I have briefly shown through the history of MRI, remain intimately tied to hierarchical (often also imperial) imaginative geographies that are produced by certain maps.

Excavation of entangled histories and connected trails thus serves two purposes. It shows that technoscientific research is entangled with trans-border flows of people, knowledge, technologies, financial resources, and so on. It also highlights the hierarchical, hegemonic influence of classifications (nations, societies, disciplines, sectors, etc.) that crucially affect technoscientific flows through imaginative geographies. As the EU seeks to enhance its engagement with technoscientific innovations within and outside Europe, entangled histories and connected trails can provide productive pathways in reimagining Europe alongside its technoscientific innovations and democracy.

Notes

[1]http://beta.congress.gov/bill/113th-congress/house-bill/4186/text (accessed 12 April 2014).

[2]My concern is similar to what Callon and his colleagues argue should be the focus of dialogic democracy (Callon *et al*., 2011). However, following Geoffrey Bowker, I would argue that classification and memory making (archiving) are also inherently exclusionary (Bowker and Star 1999; Bowker, 2005).

[3]Raj (2007) focusing on inter-cultural contact zones, brings to light complex and hierarchical circulations of science during European colonialism.

[4]Such a move exemplified the broader hegemony of the USA over the European technoscientific research (Krige, 2008). It also contributed to further consolidation of that hegemony.

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