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Post-Apocalyptic Citizenship and Humanitarian Hardware

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The collective practices of investing and building do-it-yourself (DIY) tools for radiation monitoring demonstrate a whole new dimension of citizen empowerment and mobilization after a disaster by involving new actors, such as so called Hackerspaces. The DIY Geiger counters and other post-Fukushima humanitarian tools introduce prototype building as a type of collective and political action driven by the ideal of a resilient, post-apocalyptic citizenship. These tools and communities organized around participatory monitoring of radiation pose constructive participatory governance lessons for more effective disaster management in the future.

Introduction

Collection and sharing of sensor data by citizens over social networking sites is commonly described as 'participatory sensing'.[1]The reasons why citizens get involved and provide data about their environment vary from science curiosity to support of ecological awareness. In the case of the Fukushima Daiichi disaster, the main focus became crisis monitoring and response. Collective online mapping during crises is not a new phenomenon but before Japan it was mainly deployed in developing countries (e.g. Sudan, Haiti and Thailand). Tools for online mapping, such as the Ushahidi platform,[2] or new organizations devoted to the improvement of new 'humanitarian technologies', like 'Crisis Mappers: the Humanitarian Technology Network',[3] have proved very useful for humanitarian projects in countries with limited resources, non-existent infrastructure and no or limited government emergency response teams.

But the Fukushima disaster sets an important precedent in terms of ‘participatory monitoring’ of ‘technological crises’. It stresses not only the importance of independent (radiation) data gathering but also new socio-technical practices of citizens building and investing in their own tools, which made this effort different from anything seen before in terms of citizen mobilization over data. The collective practices of investing and building do-it-yourself (DIY) tools for radiation monitoring demonstrated a whole new dimension of citizen empowerment, which goes beyond issues of data and introduces prototype building as a type of collective and political action. The DIY Geiger counters and other post-Fukushima humanitarian tools enabled a unique case of citizen mobilization after a disaster. The independent collection and crowdsourcing of data together with building open source and DIY tools became a form of a political right, similar to the concepts of freedom of speech and information (Peterova 2011), which aim to strengthen individual but also collective understanding and responsibility, in this case, for the environment.

This chapter is based on our study of three key activities of participatory radiation monitoring and their relation to the Hackerspace movement and development of open source hardware prototypes. The Hackerspace movement comprises alternative and independent research and development centers known as ‘Hackerspaces’, as physical spaces in a global network in which citizens work on independent software and hardware projects funded by themselves or by way of online (crowdfunding) tools and the leveraging of skills and resources. These creative environments support so called ‘hacking’, which means modification and building of open source tools, and any form of appropriation of technologies, for freely defined purposes by citizens and users themselves rather than by any corporate or business entities.

In our study, we used web ethnographic data as well as survey and interviews with the participants of two projects, Safecast,[4] and Radiation Watch,[5] as conducted between October and December 2011. Our aim was to better understand the motivations and experiences of the participants in relationship to the nuclear disaster as it unfolded, which define a new form of citizenship—‘cosmopolitical citizenship’— emerging around open source tools. We first followed the 'Safecast' project, closely related to Tokyo Hackerspace, which has a global agenda of providing citizens with accurate and independent data on radiation. Secondly, we looked at 'Tokyo Hackerspace' workshops on designing and building DIY Geiger counters and other radiation monitoring tools without any explicit support for the data. This left it up to participants to decide which platform they preferred to share data on. Thirdly, we explored the popular 'Radiation Watch' project, started by a few Japanese designers and engineers with cheap and simple DIY kits without expensive Geiger tubes. These tools were later developed into a product that anyone could buy and use with a mobile application for sharing data.

These three examples, which we will discuss, helped us to identify the importance and the effects of the new socio-technical practices upon the changing idea of citizenship in an almost post-apocalyptic situation. The social networking sites, but also the DIY tools and open source hardware practices, which arose during the course of the Fukushima Daiichi disaster, enabled citizens who accessed them to better deal with the crisis and the limited information broadcast by the official response team, on a very personal and day-to-day basis. The social, political and technological aspects of this citizen mobilization employing DIY open source tools and the online services for sharing data stressed the notion of responsible and active citizenship. That is, responsible citizenship was performed through DIY practices of building tools and sharing data independently of both governmental and non-governmental bodies.

More broadly, in fields of knowledge study, this new grassroots response to a disaster brings together investigation of newly emergent social phenomenon, behavior and practices through science, technology and society (STS) studies on risk and uncertainty (Beck 1994, Giddens 1991), with science communication and policy studies on public participation in science and technology (Jasanoff 2003). The approach, which we decided to take to understand the convergence between citizen science projects and issues of uncertainty and risk after a disaster, was mainly informed by actor network theory—or 'ANT' (Law and Hassard 1999). This approach provides a suitable framework for exploring the emergence and significance of DIY tools and open source hardware in enabling this new type of citizen empowerment.

Actor network theory would view these novel socio-technical tools as 'hybrid networks' involving human and non-human actors, which have equal weighting and ability to influence situational outcomes and processes. The outcome was that DIY hacking practices as forms of citizen mobilization and empowerment enabled more decentralized and novel forms of disaster management and emergency responses (cf. Schmid this volume). 'Citizenship' in such hybrid networks—rather than serving some predefined ideals of emancipation based on gender, social inclusion, or other socially defined concepts—is defined as an experiment in bringing together accessible technological possibilities with human interests and social needs. The ANT concept of hybrid networks, based on the 'generalized principle of symmetry' between society, nature, and technology (Latour 1993), helps us to understand better these emergent forms of public participation in science and technology, which we identify here as the Hackerspace and DIY movement. The need for independent data could not possibly be fulfilled without utilizing open source hardware tools.. These were not originally conceived as social or political technologies, but as prototype devices for testing new design ideas, to be later manufactured on a larger scale. The tools enabled an unprecedented form of citizen activism post-nuclear disaster. They entered the everyday life and practices of a large number of lay users through workshops and online support groups changing traditional notions of citizen participation and involvement in crisis. The hybrid network created around Hackerspaces, which supported the building of DIY Geiger counters and sharing of independent data, gave equal agency and importance to the various actors in this post-apocalyptic situation.

The independent, citizen science activities after the disaster were political, social, and technological interventions happening simultaneously. They depended on the open source hardware tools as much as on the active and motivated citizens. This is why we call them 'cosmopolitical' (Latour 2004) and refer to the more normative view of the hybrid networks in ANT, which not only explains the events and the networks ex post but tries to open a question of how to support and design certain politics around new social actors. Building new tools as a way of introducing new actors in the case of this disaster enabled citizens to gather independent data on radiation directly and to create new networks and actions around this without governmental or non-governmental help. That is, it was not a simple technical solution to a predefined and given problem but a normative 'event' and intervention, a process of empowering citizens to define new common goals and questions in a situation of crisis by testing these tools and prototypes.

The DIY activities around open source hardware thus enabled citizens to both challenge and build on the official radiation information being issued by government and non-government agencies, which many commentators considered inadequate for understanding the spread and effects of radiation at the local, street and neighborhood levels (see also Morita et al. this volume). The resultant participatory radiation monitoring activities were not only a political venue of citizen protest and mobilization, but also served other functions, for example, a type of ritual of gaining symbolic power over the circumstances, which improved people's morale and capacity to better face and cope with crisis. Building and using Geiger counters in some cases also reflected the act of creating and using a 'fetish' object (Kera 2012), which connected the concrete, material tool and radiation issue with deep seated fears, hopes, and emotions, which were all difficult to deal with. Overall, the various functions of these participatory DIY crowdsourcing practices extended the idea of community and responsible citizenship. The broader outcome is that after the Fukushima Daiichi disaster, the traditional notions of responsible and caring community, such as voting, self-organization, freedom of expression, and solidarity, became extended through hybrid, socio-technical practices, as illustrated in building radiation monitoring tools for data gathering and sharing of data.

Open source hardware mobilization

The loose and hard to define network of geeks, curious citizens, and amateur scientists, which emerged after March 2011, showed for the first time the real potential of the so called Hackerspace movement as a platform for grassroots politics and innovation.[6] Tokyo Hackerspace was especially quick to respond to the Fukushima Daiichi disaster and effectively created a new model of crisis management. It enabled concerned citizens to join forces with designers and members of the broader international Hackerspace community to build independent tools for gathering and sharing radiation data. Through a series of workshops and 'kits'—sets of simplified electronic parts, which can be assembled into a functional tool—Tokyo Hackerspace shared instructions with lay people on how to build and tinker with Geiger counters and radiation data.

This innovative case of participatory sensing of environmental data (e.g. of air pollution, soil pollution and water quality) extended the notion of citizenship. It started a 'citizen science' movement, which we describe as 'participatory monitoring of radiation'. Common participatory sensing and monitoring is an emergent trend in citizen science projects seeking greater involvement of lay people in participation and decision making about their habitat (Paulos et al. 2009). Alternatively, the post-disaster monitoring radiation network could be described as a grassroots and decentralized socio-political movement on radiation issues that emphasized cooperative, data and knowledge sharing, which enabled small efforts to have big impacts. When visualizing the collective results on a map—Google map (see also Morita et al. this volume),[7] or Google Earth[8]—or a visualization interface—e.g. IBM Many Eyes[9]— a new sense of a community action and collective power was created.

It could also be seen as a 'technological movement' in terms of its insistence on DIY open source tools distributed through kits,[10] and social software online services. In other words, the Fukushima Daiichi grassroots radiation monitoring integrated the crowdsourcing and participation over data with new technological trends—open source hardware and software platforms, such as Arduino,[11] or Pachube,[12] and other Do-It-Yourself (DIY) and Do-It-With-Others (DIWO) approaches for building DIY Geiger counters. These trends and approaches are part of Hackerspace culture and its connections to the MAKE magazine (since 2005), and Maker Fair events (since 2006),[13] which play an essential role in this emergent alternative research culture. The decentralized radiation monitoring by citizens over these DIY open source hardware tools changed the meaning of active and responsible citizenship from a communicative act (discussing data) to a material practice (of building tools and prototypes). It served as a means of solving immediate and worrying problems related to the lack of independent data and public knowledge about radiation related to inadequate official information on radiation, and became a unique platform for citizen mobilization.

As such, we argue this new and emergent form of public participation on controversial techno-scientific problems—here, on the spread and effects of nuclear radiation and what is the best course of action to address and cope with it—changes our views of what it means to be a citizen, which also helps to provide a resilient participatory approach for a possible post-apocalyptic world. In a world of the 'internet of things' (Gershenfeld et al. 2004, Greenfield 2006, Weiser 1993), and 'crowdsourced data', grassroots science citizenship appears to radically extend the notion of political participation based on communicative acts of discussing, deliberating and voting. It also involves 'giving voice' to non-human actors in our environment (Latour 1993, 2004), through sensors, open source hardware, and various online tools. More broadly, this socio-technical citizenship can be described as 'cosmopolitical' (Latour 2004), as it defines public participation and civic engagement in terms of our involvement with non-human actors through building prototypes and using DIY open source tools to measure radiation risk. It connects politics and social interaction with building tools but also managing data from things and objects.

As such, post-Fukushima Daiichi decision-making processes changed and transformed the elaborate divisions of expertise between government institutions, universities, research centers, and non-profit organizations. At the local level, many citizens independently made small, individual decisions based on their Geiger counter measurements of radiation on how to move around, where and what to eat, and how to work and live under the constant threat and risk of radiation pollution. To best understand the emergence and significance of these micro-decisions and -policies of individuals and small communities we saw the need to discuss the public and private functions of DIY grassroots efforts and strategies related to participatory radiation monitoring. For that purpose we compared the available information and data available on the Internet about the two main initiatives and projects with the interviews we conducted with the citizens who took part in the radiation monitoring efforts of Safecast and Radiation Watch.

Participatory sensing of radiation

The emergent practice of participatory sensing of radiation fits into the more established field of participatory environmental monitoring and sensing, as a standard citizen science practice with impact on both technoscience and policy (Hedgecock 2009, Paulos and Jenkins 2005). This field includes mobile sensing (Goldman et al. 2009), urban sensing (Campbell et al. 2006), and concepts of ‘participatory urbanism’ (Paulos 2005), which fits sensors into the design of cities and neighborhoods. Prior participatory sensing research focused largely on air pollution (Hooker et al. 2007, Peterova 2011, Saavedra 2011), which seriously affects the quality of life in many cities, with Hong Kong, Mexico City, Manila and Beijing being outstanding contemporary examples.

It is relatively easy to ‘sense’ at the amateur DIY level thanks to cheap sensors for CO^2, NO, NO^2, SO and SO^2. The tools for participatory monitoring are usually explicit (handheld devices) or passive (vehicle-mounted sensors) and they record geo-referenced environmental data in places where people live or go, rather than where scientists might expect them to be (Hedgecock 2009). This increases the amount of information and resultant impact on public life as it targets more specific areas that people feel personally connected with and in charge of. This affects everyday life and social interactions. When neighborhoods start to independently monitor and collect data in real time, as was the case after Fukushima, they also become more resilient and interested in capacity building through more tools to manage their situation. Rather than waiting for a centralized authority to intervene, which can take a long time and be inappropriate at the local level, citizens post-Fukushima became more aware and more willing to act and innovate at the grassroots level and demanded change based on their independent data.

However, immediately after the disaster, there were neither enough Geiger counters or other reliable tools to gather information on radiation levels in contaminated areas. Citizens had to start building their own devices and to reflect upon their imperfections by calibrating them and figuring out their reliability. The resilient response of these citizens is apparent not only from crowdsourcing and building tools efforts, but also from the financial support they raised from the global community by way of 'crowdfunding' websites.[14] Crowdfunding is a relatively new term, which describes public and global fundraising for innovative projects enabled through dedicated websites. Crowdfunded projects usually offer something in exchange, which, in the case of Fukushima, became an *actual* Geiger counter, used in workshops to teach people how to build it and calibrate it for later use to collect accurate and detailed data.[15]

To reiterate, affected citizens began independent radiation monitoring efforts as a response to inadequate official versions of radiation data for private consumption (also see Morita et al. this volume), as they did not identify many random, high radiation concentrations called 'hotspots', which were sometimes quite hard to detect, for example:

> The hotspot, a small area of about one meter radius, was found in a vacant lot in Kashiwa. Radiation levels of 4.11 microsieverts per hour were detected one meter above the surface of the soil, equivalent to some areas in the evacuation zone around the crippled nuclear power plant. Up to 450,000 becquerels per kilogram of radioactive substances were detected in the soil below the surface, an Environment Ministry official said, Fuji TV reported. (Japan Today 2011)

Kashiwa is located 195 km from Fukushima, on the outskirts of Tokyo in Chiba prefecture. Subsequently, hotspots became the main target of participatory radiation monitoring efforts. Official versions were also often late in providing information. Reliability was further undermined where fixed sensors, although accurate were sparse, and the released data was often based on interpolation rather than measurement.

Weather conditions including sunlight, rain and wind can also facilitate atmospheric conditions for the formation of hotspots. While radiation travels with dust particles by wind or water, it tends to accumulate in drains and ditches both in natural and urban areas. Because of these unpredictable effects and hotspots, participatory radiation by citizens crossed the boundary of radiation monitoring being the sole domain of experts and policy-makers. Citizens used their tools to become ‘ad hoc policy-makers themselves’, and make decisions which would contribute to the health and safety of their streets and neighborhoods. The DIY Geiger counters became a type of ‘technopolitical tool’ (Goodman 2009), which transformed ‘citizens as consumers of data’ into active and responsible public actors providing highly localized information to their communities (see also Bäckstrand 2003).

Humanitarian Hackerspace workshops in Tokyo

The transformation of consumers of data into public actors was done not only by data sharing practices but also through building and developing open source tools, as in the Tokyo Hackerspace workshops. The importance of the open source hardware as a novel response to the disaster is apparent from the online materials related to the Tokyo Hackerspace events (Akiba 2011, 2011b). Almost immediately after the Tohoku earthquake and tsunami, and during the disaster itself, Hackerspace members had several meetings to discuss how to help the affected areas. The first humanitarian hardware project of Tokyo Hackerspace, Kimono Lantern Kit, was a solar rechargeable lamp originally designed as a decoration for gardens, which was quickly mass produced and distributed in areas suffering from blackouts.

This special form of local activism was later termed ‘Humanitarian Open Source Hardware’ (Akiba 2011). The lantern project served as a model for developing the subsequent DIY radiation sensing devices, the various DIY Geiger counters (iGeigie, the iPhone Radiation Dock, Ion Chamber Radiation Detector Kit). Below is a description of one of the first Hackerspace meetings, which demonstrates the close connection between attempts to design open source hardware tools and activist ambitions to help the affected areas. It expresses the motivation and empathy mixed with very practical concerns on what is needed in terms of technical, financial and other support:

> In the hackerspace, we'll be holding our meeting tonight and will probably start hammering out plans to figure out how and where we can help … So although it's outside the original sphere of intended use, it looks like the simple Kimono lanterns we designed can play a small role in providing comfort and at least give a small feeling of safety to people that are going through this horrific experience … I’ve updated the files to v1.1 and the package includes the BOM and full gerbers. It’s a turnkey package that can be taken and sent directly to the PCB fab. (Akiba 2011)

Bringing the open source lamp to the people in the affected areas was not a purely utilitarian task but more an attempt to bring a feeling of safety after trauma, to give a feeling of control over the circumstances. It is an example of what we call a ‘fetish’ function of the humanitarian hardware, which is even more obvious in the case of the DIY Geiger counters. Like indigenous culture fetishes, these objects have almost a ‘magical power’ to provide comfort in times of uncertainty. People monitoring radiation around their houses and neighborhood are aware that they are not protected from the physical effects of radiation but at least psychologically and mentally they feel protected from the uncertainty and chaos and hold onto the hope they can manage and improve their circumstances. The DIY radiation monitoring devices simply enabled a basic control and comfort, also related to a feeling that people were not alone but had the support of a global community.

The first Geiger counters were donated to Tokyo Hackerspace by Reuseum, a company with close connections to US Hackerspaces (Reuseum 2011). After receiving these Geiger counters and improving their functionality, Tokyo Hackerspace distributed them to organic farming communities that needed accurate radiation data on their crops (Reuseum 2011). The Geiger counters were thus a global response of the Hackerspace movement and network, which demonstrated a belief system based on distributed and decentralized solutions that improved, in both a social and technical sense, the response offered by the Japanese Government or the NGOs concerning access to local radiation data.

The efforts organized by Tokyo Hackerspace were also connected to the RDTN.org (later named Safecast[16]) network, which began a week after the earthquake and nuclear meltdown. Safecast crowdsourced data over the Pachube platform to provide accurate sensor information to citizens about radiation levels issuing from the meltdown. Safecast also raised money through the crowdfunding website Kickstarter,[17] to buy more Geiger counters and create a sensor network providing finer-grained data as an addition to the official but unreliable stationary sensors. The data from the hacked Geiger counters and other DIY devices was then disseminated through a Google map and a Google earth layout (also Morita et al. this volume), and on various other platforms listed on the website GeigerMaps.[18] These highly organized efforts thus emerged as civic interests in how to best measure the immediate surroundings, identify radiation hotspots, and how to share and critically evaluate these measurements and their risk to health. The complex networks between Hackerspaces and these online services in the aftermath of Fukushima is an important disaster case study showing the possibilities of the global response and management of crisis by citizens equipped with sensing technologies. In more detail, what were their motivations, functions and uses?

Safecast and Radiation Watch networks of participatory radiation monitoring

To understand the individual motivation and various functions and uses of these radiation participatory monitoring devices and maps we conducted a questionnaire survey and semi-structured interviews over e-mail with 16 respondents from the two local citizen networks Safecast and Radiation Watch. They were highly active in participatory monitoring of radiation after the Fukushima Daiichi meltdown. Before presenting our findings, we first provide some background on Safecast and on Radiation Watch.

Safecast is an independent group of approximately 100 enthusiasts with connections to Tokyo and US Hackerspaces, aiming to produce high-precision open data. The participants ranged from students and professionals from technical fields, to activists, designers and businessmen. The group began soon after the disaster to empower people following the problematic communication of TEPCO and Japanese government in the weeks following the disaster. The group remains in operation monitoring various areas around Japan, and has extended voluntary monitoring to other countries, for example, measurements were conducted around the San Onofre nuclear plant in California early in February 2012 after a reported minor radiation leak.

The measurement equipment ranges from handheld devices to static sensors. Once data were gathered, they were published on the safecast.org website. A staggering 2,523,635 hits were made following the inception of Safecast on March 25, 2011, to February 21, 2012. Safecast uses professional grade measuring devices and had (at the time the survey was conducted) 85 mobile and handheld devices as well as 50 static sensors. The project was initially funded by the Kickstarter fundraising website but acquired funding from other sources as well, including private investors and universities, such as Keio University and its ‘Scanning the Earth’ project.[19] We accessed and interviewed Safecast members by way of its mailing list over the course of the Fall (typically August–October) of 2011.

The second group of participants interviewed was recruited from the group Radiation Watch,[20] with approximately 1200 members that exchange radiation data.

Radiation Watch also aims to empower citizens by integrating radiation measuring into an *everyday practice*, through shared technology, which enables people to produce data themselves to make radiation monitoring highly accessible. The group, which comprises of volunteering engineers, designers and scientists, designed a DIY iPhone accessory that can achieve precision similar to standard Geiger counters. The device later evolved into an actual product that no longer needs any DIY skills and can be plugged into Apple devices to measure radiation. Radiation Watch operates a Facebook group for communicating and organizing group members.

To better understand the motivations behind participants measuring radiation data, how these local practices started, and how the data shaped the opinions of respondents during the measurement process, our questions were organized into five key themes suggested by the situation, the process and findings of which we now discuss.

Theme 1: motivation to measure

We first asked about the participants' motivations for undertaking radiation measurements. A most interesting finding was the difference between Safecast and Radiation Watch members' aims. Safecast members aimed to publicize the data to the *general public*, while Radiation Watch members aim was to empower *individual citizens* with their own devices to measure radiation. 'Safecasters', as we nominate them, started measuring radiation as early as March 12, 2011—one day after the nuclear disaster. Their motivation was to 'make radiation data available to the public', as an alternative to 'government and [other] internet [sources]' (participant 1). Most Radiation Watch members, however, started relatively late after the disaster, mainly during the second half of 2011. We surmise this was partly caused by a gradual development of the design of the DIY iPhone accessory, later offered to the general public. One interviewee of Radiation Watch noted how he, 'only started measuring when I got a tip on a cheap Geiger counter from a friend of mine during the fall' (participant 7). The 'cheap Geiger counter' refers to the 'Pocket Geiger'; one of the first devices that attracted the attention of a large number of citizens, not only geeks related to Tokyo Hackerspace or Safecast. The easy access technology design of measuring tools and services for sharing data, such as making them work with devices that users were accustomed to, such as iPhones or iPods, well facilitated the growth of citizen science monitoring.

Aligning to its focus on the individual, the motivations of Radiation Watch members also tended to relate to personal goals; '[I started to be interested in measuring] when I heard my friends, having three kids, were worrying about radiation ... [I] wanted to know if my neighbourhood was safe enough or not. And [I also] wanted to have my own resource to make decisions' (participant 1). Another participant mentioned she started measuring radiation during the summer, around the time when there were reports on radiation in food: 'I am in Nagoya, far away from Fukushima, but I know that food travels, people travel, gardening soil travels, and I thought it is best to start testing things on my own' (participant 2).

In being asked about their original sources of data prior to starting their own measurements, most Radiation Watch participants responded they had initially relied on official data published by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), as cited in various media, but had found it too technical as well as not being collected at enough locations. One participant noted that prior to engaging with personal radiation monitoring, she began searching for alternative information sources such as Safecast and Radiation Watch, and the availability of the cheap monitoring devices motivated her to buy one and participate actively. She wanted to contribute to the community as much as she wanted to know what the situation was in a given neighborhood for her own activities. The second most common and associated reason for starting to measure related to feelings of insecurity about the radiation spread within the immediate living environment. In this case, buying the radiation monitoring equipment and measuring become more of a ritual of receiving some comfort, which we saw as a 'fetish' function of these DIY tools.

Theme 2: creating and sharing open data

The second question related to identifying with monitoring and sharing radiation data. We presented interviewees with five potential answers to rank on a Likert scale from 1 to 5 where 5 represented ‘strongly agree’ or ‘most important’ and 1, ‘strongly disagree’. Opinions were very diverse on the issues of ‘distrust and protest against government’ and ‘distrust in TEPCO and media coverage’, with replies spread robustly across the scale. This variation we attribute to both foreigners and Japanese surveyed having various opinions on how trustworthy the official data were. This meant that most people did not decide to start measuring radiation because they mistrusted government data, but because they were interested in better granularity and precision, mostly concerning their immediate surroundings and places where they spent most of their time—the house and garden, the playground and park. A high number of positive answers (strongly agree) on another question on the ‘need for more precise data about particular exposure in locations’ supported this proposition. One interviewee stated: ‘Concern of radiation around my house was the biggest reason. Nobody would come to measure to see if there was a hotspot in my garden’ (participant 3). Local ‘hotspots’ became an important topic in the Japanese media soon after the disaster. They started appearing at various locations where rainwater flowed, often, and surprisingly, far away from the Fukushima Daiichi reactors and close to Tokyo; with some discovered by citizen sensing activities. Some participants placed a high importance on the concept of ‘open data’ and wanted to know more about data collection methods. The expressed belief was that these data were important both to citizens as well as ‘governments, companies and researchers’, because all could team up to ‘benefit (from the data) and tackle the problem in a more cohesive and creative manner’ (participant 4).

The impression, therefore, that these answers give is that measuring radiation was not a type of protest or distrust in government and official authorities carrying out measurements but an effort stimulated by a need to do something, to participate, to be part of the solution, to be useful to the community, to have a feeling of empowerment through participation at a time when personal empowerment was seriously compromised by the scope and gravity of the nuclear disaster, and to contribute to more accurate readings at the personal local level. These reasons tend to expand our notion of the 'fetish' function of Geiger counters, as people are aware that they can do little about the effects of radiation but they still like to measure it. Overall, the majority of respondents leaned towards becoming more cautious and feeling less comfortable in being in areas of possibly increased radiation which they had not measured. Conversely, they were more comfortable about walking and inhabiting places where they had measured radiation levels to inform their actions. Measuring, gathering and aggregating data and interpreting their meaning thus made people more aware of the effects of radiation. A typical reaction was that 'measuring allows oneself to see what is happening and takes away the mystery and with that most of the fears' (participant 1). Accordingly, this created the impression of empowerment linked to personal safety and comfort for most participants.

Theme 3: evaluating the data and experience with measuring

The most important benefit that participants mentioned was that measuring and knowing the radiation levels in their immediate surroundings created a feeling of control of the situation, a form of empowerment over concerns, such as consuming locally produced food. Many of them also mentioned that now they felt they knew much more about radiation, which comforted them. One respondent stated:

> Even though I am not an "expert", I can say my area is safe enough based on the knowledge I collected and numbers that my DIY machines reported. Additionally, I gained ability to judge if (officially) provided information is correct or not. (participant 1)

Theme 4: accuracy of citizen science data

The issue of validity of data gathered by citizens was highly recognized by the respondents. One respondent described the attitude of the official scientists and media towards citizen scientists as dismissive and he felt discouraged because his data was labeled as amateurish and thus questionable (participant 4). But another respondent took this as a reason ‘to contribute and make monitoring easier to be used by more people. This included measurement protocol standardization and consolidation of [our] database with other efforts’ (participant 10). The citizen scientists were quite aware of the issue of data accuracy and its usefulness, and considered ways to ensure precision, such as improving measuring devices to automatically log additional metadata about the measurement location by which to compare data from other devices. One participant also expressed disappointment that not only Japanese but also foreign media ignored the data collected by citizens: ‘I have been following the mainstream media—in English—quite intensively (Japan Times, Asahi, NHK, Mainichi, Kyodo, etc.) and do not recall ever having seen an article that includes data collected by citizens. I think it is generally ignored’ (participant 2).

A noticeable difference was apparent in the responses on this topic between Safecast and Radiation Watch participants in terms of their assessment of data accuracy and the function of monitoring. One Radiation Watch respondent commented:

> They [traditional researchers] usually deny amateurs and dispute our data, but I just want to know if my place is safe or not (I do not need to know if my place is 0.05uSv or 0.06uSv). In my opinion, they struggle to explain their data in plain Japanese. (participant 1)

This statement emphasizes the role of language in constructing the meaning of data for accessible everyday consumption, which was ignored by official measurements, and was another key reason for citizen monitoring efforts. This was because the majority of people did not have any technical education in this field, and they struggled to understand the data gathered by the official institutions.

Safecast respondents, whose focus was more technical and professional, were more certain about the validity of their data and had a more positive view of how their data was being evaluated by the science community and media: ‘We have had a positive response from researchers and our system is being used by multiple research teams’ (participant 1). The difference in perception of data validity related to the focus of both groups. Safecast was always more interested in developing and following rigid methodologies for radiation measurements and using higher grade instruments, while Radiation Watch was more concentrated on crowdsourcing and involving individuals.

Theme 5: future citizen science

This theme focused on the overall experience of monitoring and probed whether this motivated the participants to be involved in any community projects related to citizen science in the future. More than 75% of the respondents said they wanted to continue to measure radiation. A typical response was: ‘It is something that will likely influence us in the near future, over the next 30 years or so’ (participant 5). Another participant mentioned the safety and well-being of his children as the motivating factor to continue: ‘Now I want to know if my place is in the same situation as Fukushima, and what I should do first to save my kids (from health risks in the future)’ (participant 1). Yet, another respondent pointed out the potential of other nuclear disasters like Fukushima Daiichi in seismically unstable Japan:

> I will continue to monitor my own vicinity. Since Nagoya is located between Monju and Hamaoka, I think it is advisable to become familiar with how to use a monitoring device and to understand the readings … just in case we have a similar accident here (participant 2).

The Hamaoka nuclear power plant has two reactors, constructed in 1971 and 1974 respectively. The reactors sit above a major fault line (on this topic see also Hara in this volume) close to the location of the expected epicenter of the next Tokai earthquake. Earthquakes occur regularly in the Tokai region, with an interval of 100–150 years between quakes and the next one is expected to be magnitude 8 with a 70% chance of the quake recurring in 2012.[21] As such, there has been an on-going effort by the local government to shut the plant down to minimize the potential of another disaster similar to the one that hit Fukushima Daiichi.

In their involvement in future radiation endeavors, Radiation Watch participants again put personal safety and self-empowerment as their main interest, while Safecast members emphasized developing a large scale independent and alternative measurement network—as one respondent put it: 'The goal is to expand to cover Japan entirely and worldwide and repeat measurements to catch radiation trends' (participant 1).

Another question probed what interviewees saw as the most viable citizen science projects for the future based on their experience with radiation monitoring. All respondents had a positive opinion about the potential of crowdsourcing of data and support platforms to share data. One respondent stated: 'I believe that crowdsourcing data collection is the way to go. It is more and more important to collect meaningful data' (participant 6). Another respondent mentioned the importance of collective efforts to achieve bigger goals as the way for the future: 'This is how the future will be—many small efforts can easily become a big one with the help of technology and open thinking' (participant 1). Another respondent expressed a more radical approach that deeply questioned the public credibility of government and corporate radiation monitoring efforts: 'I think it [civic radiation monitoring] will become more widespread, especially as citizens become more frustrated with the obfuscation of the facts by the government and corporations [like TEPCO]' (participant 2).

The differences expressed between Safecast and Radiation Watch participants led us to explore these differences in more depth.

Comparing Safecast and Radiation Watch

While Radiation Watch participants were mainly concerned with individual self-empowerment and their immediate and personal situations, Safecast members developed a more activist and collectivist approach to deal with the whole impact of the Fukushima Daiichi disaster. Instead of focusing on individual areas, Safecast focused on mapping the total areas affected. This made them more motivated to work with multiple stakeholders, including professional ones, which Radiation Watch ignored to focus on the data from a large number of citizens, mainly interested in their own spaces. Arguably, a more individualized attitude to radiation monitoring and crisis reflects the thrust of ‘reflexive modernisation’ (Beck 1994), with all its ambiguities of individualization, universality of risk, and homogenization based on safety.

By way of contrast, the participatory monitoring efforts of Safecast placed higher emphasis on collective hacking of hardware and other DIY activities, and attempted to create a ‘global’ consensus and support for independent data measurements through the Hackerspace network. It thus aimed to empower not only individuals but also communities in a more radical and ‘agile’ way (Ito 2011). More broadly, Safecast represented an effective international response to a crisis in terms of accessing the needed resources (money and tools) for civic monitoring of radiation. As such, we believe the Safecast movement embodies the ideas of ‘cosmopolitical citizenship’ as civic action based on designing and building new tools to support various functions rather than the more ‘anxious’ individual ‘reflexive modernisation’ approach to radiation monitoring.

The participatory monitoring efforts over Geiger counters and similar low tech solutions in both cases, however, show how difficult it was to get accurate radiation data and decide on appropriate courses of action to cope with the post-nuclear disaster situation. In this context, participatory monitoring was not only about the crowdsourcing of data and dispersing individual and collective anxieties, hopes, and fears, but also about creating a more critical attitude and realistic expectations towards technologies in terms of understanding their limits. We think that this understanding of the DIY technologies enabled citizens to become more resilient and agile in their response and expectations (more typical of the Safecast users). Another function of the DIY tools (more apparent in the case of Radiation Watch) was to empower citizen users at a more private level, where tools were also more a type of fetish, as therapeutic devices for a post-apocalyptic ritual of catharsis and healing with elements of personal protest and reflection Kera 2012In this sense, the DIY monitoring of radiation tools represented modern day fetishes and power objects with the ability to connect anxiety and hope, provide symbolic and real power over chaotic circumstances, and link scientific data with primal human emotions to build local capacity to deal or cope with very trying post-apocalyptic circumstances.

Conclusions

The participatory monitoring of radiation in Japan after the Fukushima Daiichi nuclear disaster poses a unique case of local and citizen social and technical convergences and synergies, which pose a resilient model for emergent post-apocalyptic citizenship. This finding is particularly revealed in investigating the synergy between the loose and global network of geeks from the Hackerspaces with post-nuclear disaster citizens (victims) in Tokyo, which led to the creation of 'humanitarian hardware' tools and enabled participatory monitoring of radiation. Tied to this were emergent online platforms for crowdsourcing and crowdfunding, which provided necessary resources for participatory monitoring. This complex, socio-technical infrastructure of open source hardware tools, online services, cooperation around and workshops in the Hackerspace, evolved very quickly after the disaster.

This dynamic infrastructure, which no official government or non-government actors would have anticipated, enabled citizen volunteers to begin grassroots radiation crowdsourcing efforts. These political and decision-making efforts at the grassroots level were always closely linked to processes of designing, building, and testing prototypes, including DIY Geiger counters and special lamps. Participatory monitoring of radiation thus amounts to a form of political and collective action around prototypes, which defines its politics as a form of design or socio-technical experiment. The various functions of the designed tools, from the more pragmatic (identifying hotspots) to the more symbolic (gaining symbolic power in a situation of uncertainty) evolved through these socio-technical experiments. Rather than defining the future collectives in terms of risk, discipline, normalization, or biopolitics, these functions enabled a 'cosmopolitical' citizenship to emerge in the form of pragmatic and plural collectives around DIY tools with various, even conflicting goals and aspirations, especially in domains of the private and public. As such, citizen participatory radiation monitoring offered a more resilient and agile model for dealing with the complexity and uncertainty of radiation pollution in Japan. More broadly, the emergence and significance of DIY tools and open source hardware in enabling a new type of citizen empowerment, as vividly displayed in the case of the Fukushima disaster, poses constructive participatory governance lessons for more effective disaster management in the future.

Notes

[1] We discuss the concept in further detail on p. XXX in chapter 'Participatory sensing from Data to Hardware Hacking' (Goldman et al. 2009; Campbell et al. 2006; Paulos 2005).

[2] Ushahidi is an open source tool to crowdsource information using multiple channels, including SMS, email, Twitter and the web http://www.ushahidi.com/ (accessed July 27, 2012).

[3] Crisis Mappers: The Humanitarian Technology Network, accessed July 27, 2012, http://crisismappers.net/.

[4] Safecast, accessed July 27, 2012, http://blog.safecast.org.

[5] Radiation Watch, accessed July 27, 2012, http://www.radiation-watch.org/.

[6] An important role in the convergence of research and activism was played by global networks of individuals involved in Hackerspaces (Kera 2012), as a network of co-working spaces in almost 500 cities worldwide inspiring various types of grassroots 'hacktivist' projects connecting citizen science with some form of monitoring and crowdsourcing of data or hacking tools.

[7] Google Maps, accessed July 27, 2012, https://maps.google.com/.

[8] Google Earth, accessed July 27, 2012, http://www.google.com/earth/.

[9] IBM Many Eyes, accessed July 27, 2012, http://www-958.ibm.com.

[10] "Open Source Hardware Definition (OSHW) 1.0," Open Source Hardware, accessed July 27, 2012, http://freedomdefined.org/OSHW.

[11] Arduino – popular open-source single-board microcontroller used for the DIY Geiger counters: Arduino, accessed July 27, 2012, http://www.arduino.cc/.

[12] Pachube is an online database for sensor data and platform for building applications using sensor data on the environment Pachube was relaunched under the new name 'Cosm' in May 2012: https://cosm.com/.

[13] Make magazine http://makezine.com/ and Maker Faire http://makerfaire.com/ (accessed July 27, 2012).

[14] Kickstarter, accessed July 27, 2012, http://www.kickstarter.com/.

[15] RDTN.org, "Radiation Detection Hardware Network in Japan," accessed July 27, 2012 http://www.kickstarter.com/projects/1038658656/rdtnorg-radiation-detection-hardware-network-in-ja.

[16] Safecast is a global sensor network for collecting and sharing radiation measurements to empower people with data about their environments. Safecast, accessed July 27, 2012, http://blog.safecast.org/.

[17] Kickstarter, accessed July 27, 2012, http://www.kickstarter.com/.

[18] Japan Geiger Maps, accessed July 27, 2012, http://japan.failedrobot.com/.

[19] See details at www.scanningtheearth.org (accessed July 27, 2012).

[20] Radiation Watch, accessed July 27, 2012, http://www.radiation-watch.org/.

[21] See http://en.wikipedia.org/wiki/T%C5%8Dkai_earthquakes (accessed July 27, 2012).

References

Akiba. "Kimono Lantern and Humanitarian Open Source Hardware." FreakLabs, 2011a. Accessed June 10, 2012. http://freaklabs.org/index.php/Blog/Misc/Kimono-Lantern-and-Humanitarian-Open-Source-Hardware.html.

Akiba. “Update From Akiba @ Tokyo HackerSpace.” Reuseum, 2011b. Accessed June 10, 2012. http://www.reuseum.com/2011/04/update-from-akiba-tokyo-hackerspace/

Bäckstrand, K. “Civic Science for Sustainability: Reframing the Role of Experts, Policy-Makers and Citizens in Environmental Governance.” Global Environmental Politics 3, no. 4 (2003): 24–41. http://www.mitpressjournals.org/doi/abs/10.1162/152638003322757916.

Beck, U. “The reinvention of politics: towards a theory of reflexive modernisation.” In Reflexive Modernisation, edited by A. Giddens, S. Lash, and U. Beck. (1994): 1–55.

Campbell, A., et al. “People-centric urban sensing.” Proceedings of the 2nd Annual International Workshop on Wireless Internet WICON 06 12 (4) (2006): Article 18.

Gershenfeld, N., Krikorian, R., and D. Cohen. “The Internet of things.” Scientific American 291 (2004): 76–81.

Giddens, A. Modernity and Self-Identity. Cambridge: Polity, 1991.

Goldman, J., et al. “Participatory Sensing: A Citizen-powered Approach to Illuminating the Patterns that Shape our World.” White Paper, 2009. Accessed August 29, 2012. http://wilsoncenter.org/sites/default/files/participatory_sensing.pdf.

Goodman, E. “Three environmental discourses in human-computer interaction.” Proceedings of the 27th International Conference on Human factors in Computing Systems – *CHI EA ’09*. New York, USA: ACM Press, 2009.

Greenfield, A. Everyware: The Dawning Age of Ubiquitous Computing. Berkley, CA: New Riders Publishing, 2006.

Hedgecock, R. “Mobile Air Quality Monitoring and Web-based Visualization.” MA thesis, Venderbilt University, 2009.

Hooker, B., Gaver, W., and A. Steed. “The Pollution e-Sign.” Design (2007): 1–4. Accessed June 10, 2012. http://itp.nyu.edu/sustainability/interaction/uploads/pollution_e-sign.pdf.

Ito, J. “Innovation in Open Networks.” Fora.tv, November 10, 2011. Accessed June 10, 2012. http://fora.tv/2011/11/10/Joi_Ito_Innovation_in_Open_Networks.

Japan Today, “Radiation hotspot in Chiba linked to Fukushima.” Japan Today, November 29, 2011. Accessed February 19, 2012.

http://www.japantoday.com/category/national/view/radiation-hotspot-in-chiba-linked-to-fukushima.

Jasanoff, S. “Technologies of Humility: Citizen Participation in Governing Science.” Minerva, 41(3), 2003: 223–244. Accessed July 19, 2012. http://sciencepolicy.colorado.edu/students/envs_5100/jasanoff2003.pdf.

Kelty, C. “Culture’s Open Sources: Software, Copyright, and Cultural Critique.” Anthropological Quarterly 77, no. 3 (2004): 499–506. Accessed April 1, 2012. http://www.jstor.org/stable/3318231.

Kelty, C. “Coding for Meaning.” MetaScience 15, no. 3 (2006): 535–538.

Kera, D. 2012. “Hackerspaces and DIYbio in Asia: connecting science and community with open data, kits and protocols.” Journal of Peer Production. Issue 2. Accessed August 29, 2012: http://peerproduction.net/issues/issue-2/peer-reviewed-papers/. .

Latour, B. We Have Never Been Modern. Cambridge, Mass.: Harvard University Press, 1993.Latour, B. Politics of Nature: How to Bring the Sciences into Democracy. Cambridge, Mass.: Harvard University Press, 2004.

Law, J., and J. Hassard. Actor Network Theory and After. Oxford, UK: Wiley-Blackwell, 1999.

Paulos, E., and T. Jenkins. “Urban probes: Encountering our Emerging Urban Atmospheres.” Methods 7 (2005): 341–350.

Paulos, E., Honicky, R., and B. Hooker. “Citizen Science: Enabling Participatory Sensing.” In Handbook of Research on Urban Informatics: The Practice and Promise of the Real-time City, edited by M. Foth, 414–434. Hershey, PA: Information Science Reference, 2009.

Peterova, R. “Urban Interfaces & Extensions: Sensors, Chips, and Ad Hoc Networks as Tools for Urban Culture.” MA thesis, Charles University, 2011.

Reddy, S., et al. “Evaluating Participation and Performance in Participatory Sensing.” Proceedings of International Workshop on Urban, Community, and Social Applications of Networked Sensing Systems. Paper presented at UrbanSense08, Raleigh, North Carolina, USA, November 4, 2008. Accessed June 10, 2012. http://www.ee.ucla.edu/~sasank/web/doc/sr_urbansense.pdf.

Reuseum. "Update From Akiba @ Tokyo HackerSpace." Accessed June 10, 2012. http://www.reuseum.com/2011/04/update-from-akiba-tokyo-hackerspace/.

Saavedra, J. "Modular // Neuroid: Wearable, Reconfigurable Personal Pollution Monitor." Accessed June 10, 2012. http://thesis.jmsaavedra.com/papers/.

Weiser, M. "Some computer science issues in ubiquitous computing." Communications of the ACM 36, no. 7 (1993): 75–84.