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Micro/macro prototyping ☆

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ABSTRACT

While urban computing has often been envisaged as bridging place, technology and people, there is a gap between the micro-level of urban computing which focuses on the solitary user with technological solutions and the macro-level which proposes grand visions of making better cities for the public. The gap is one of scale of audience as well as scale of normative ambition. To bridge this gap the paper proposes a transdisciplinary approach that brings together actor–network theory with critical and participatory design to create prototypes that engage people and build publics. The theoretical discussion examines a way of thinking about size as performative and shiftable through practical design methods. The micro/macro prototyping approach is demonstrated via an empirical case study of a series of provocative prototypes which attempt to build a material public around the issue of community noise at Heathrow airport. The paper suggests that this approach allows issues to be followed and engaged with, and their dynamics re-designed across different scales. This proposes a new role and scope for the researcher/designer as proactively engaging in normative shaping and supporting of real world settings which bridge place, technology and people.

1. Micro- and macro-visions of urban computing

The aim of this text is to locate a conceptual gap in urban computing and propose a transdisciplinary approach to address this gap and define a new role and scope for urban computing. The notion of transdisciplinarity I am working with in this text is taken from Nowotny (2006) who proposes that transdisciplinarity needs to provide a transgressive and socially robust knowledge that engages with and supports publics.

The paper addresses an area of computing that has been termed urban computing or urban informatics. While there are some differences between these terms (Foth et al., 2011, p. 5) they both conceptualise this area as an encounter among three entities: *"place, technology, and people"* (p. 2). It is the combination of these disparate entities which makes urban computing unique. Urban computing as first described by Kindberg et al. (2007) focuses on the possibilities and challenges of *"the integration of computing, sensing, and actuation technologies into everyday urban settings and lifestyles"* (p. 18). This computing is taken out of the home or office and taken to the *"streets, squares, pubs, shops, buses, and cafés—any space in the semi-public realms of our towns and cities"* (Kindberg et al., 2007). These complex physical and social settings involve a fluid and diverse range of users who enter and leave the urban space at different times of the day. The seminal text *The street as platform* (Hill, 2008) describes an urban environment where people's digital practices result in data flows which mesh with the physical elements of the city and create a dense bustle of humans and machines on the street, which becomes a platform for technological development and experimentation. Kindberg et al. (2007) argue that what makes urban computing different from pervasive computing is that it takes place in dynamics contexts with fluid user groups.

These descriptions of urban computing position it as a holistic bridging practice and propose it as more than just a subset of computing: it is a distinct space in its own right with specific methodologies. In order to fulfil this role of bridging, Shlovski and Chang (2006) raise the need for an engagement with other disciplines: *"we are not calling for technology designers to become urban planners and social scientists, but we do suggest that there is a wealth of research in these areas that needs to be taken into account when designing new technologies"* (p. 28). While urban computing aims to be a transdisciplinary practice there is a conceptual gap in the way it addresses issues of scale.

To identify this gap I will briefly sketch a taxonomy of urban computing practices and rhetorics. The classification I propose is based on two different types of scale, one of audience and one of normative ambition. In the diagram shown in Fig. 1 the *y*-axis represents a scale of audience which runs from addressing individuals to publics, while the *x*-axis represents a scale of normative ambition which extends from limited ambitions to large scale normative ambitions. A micro-vision in this taxonomy

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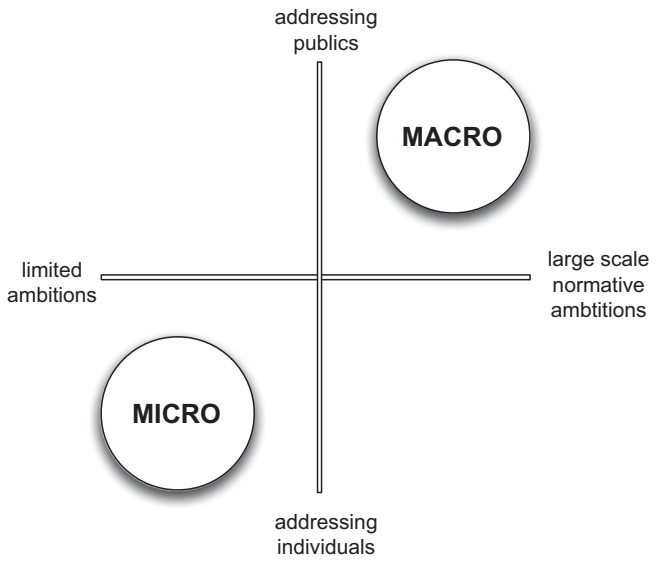

Fig. 1. Diagram that positions micro- and macro-visions of urban computing along two axes of scale. The *y*-axis is a scale of audience and the *x*-axis a scale of normative ambition.

represents a focus on individual people and individual technologies as a limited notion of transformation. In contrast a macro-vision describes a focus on social publics and proposes large scale normative transformation of the city.

To explain this taxonomy I will briefly glance across some of the literature of urban computing. One typical micro-vision scenario is the following: *"a user is in a (potentially unknown) city and would like to organise a day/night by visiting some places, attending a music concert, etc. Therefore, s/he would like to plan his/her movement to his/her destinations"* (Valle et al., 2010, p. 165). I describe this as a micro-vision since the user is framed as a solitary individual and disconnected from a social environment where they might ask other people for advice. While this scenario could be scaled up towards a mass of individuals, the fundamental assumption of the scenario is the asocial individual. In another scenario Zheng et al. (2014) describe the practical potential of urban computing for institutional management of the city by dealing with challenges such as *"air pollution, increased energy consumption and traffic congestion"* (p. 2). While this formulation rhetorically addresses big challenges, the paper is focussed on technological problems of integration and data management. I argue that this is also a micro-vision since it stays largely within the realm of the technical and does not offer large scale transformative proposals of the city.

In contrast there are other texts within urban computing that describe broader visions of the city as collective and which try to change the city deliberately. Dourish et al. (2007), for example, argue that the city is constituted through collective flows of people as social phenomena. de Waal (2011) focuses on what he terms 'urban imaginaries'. He identifies a series of these imaginaries such as the 'city of services', the 'psychogeographic city' which consists of sensation and experience, the 'city as operating system' allowing real time management, or the 'city as commons'. For de Waal these are fundamental visions of the city that practitioners are using to direct urban computing projects and thus transform the city. Iveson (2011) identifies multiple visions of citizenship when looking at systems that target urban graffiti by either informing authorities, allowing collective discussion or creating simulated graffiti. Iveson asks *"what is the vision of a good citizen and the good city that they seek to enact?"* (p. 56). These authors offer visions of urban computing for cities as collective structures and not as aggregations of atomised individuals. They make value judgements and offer an opinion-based assessment of the kind of city they want to create with urban computing. In this sense they are large scale normative ambitions for transformation and I therefore describe them as macro-visions.

My use of the terms micro and macro is not intended to indicate that one is better than another, but rather to delineate that they are very different visions of urban computing. Using this taxonomy the majority of technically focussed literature clusters in the micro-corner, while the rhetorical and theoretical visions cluster in the macro-area. While the scales I have drawn are intended to be continuous, urban computing seems to exist as two clusters with a large gap between them. On the micro-level we have computing that considers its role to be the practical design of technologies for individual users, while the macro-level consists of theoretical visions of future urbanism. This gap indicates that there is a conceptual problem in scaling between physical devices and abstract notions of a public good. I argue that this results in technical devices that are largely designed for the concept of the individual and it is left to commercial mass aggregation to build atomised public spaces.

This paper argues for a different approach to scaling which can bridge the gap between micro and macro through material technologies that are specifically designed as transformative visions of the city. The text proposes a model of micro/macro prototyping which focuses on scaling as transformative and transgressive. This approach allows material technologies to be considered at the same time as the macro and collective level. The paper will describe the theoretical underpinnings of this approach, its methods, and through an empirical case study identifies its potential and current limitations.

2. Using science and technology studies to think about prototyping

This approach builds on the work of Paul Dourish and colleagues (Williams and Dourish, 2006; Dourish et al., 2007; Williams et al., 2009; Dourish and Bell, 2011) who over many years have introduced concepts from social science into urban computing. This work has identified the conceptual blind spots of urban computing, such as groups of people who are privileged or excluded by computing. Their approach points towards ethnographic and inclusive design methods to reach more diverse groups of people. This text extends this approach by using the literature of science and technology studies (STS) and a subfield called actor–network theory (ANT) to discuss the role that design can play in 'socio-technical prototyping' (Hansen, 2006) in constructing and supporting publics that gather around issues. The notion of socio-technical used throughout this text describes the way the social and the technical are inseparable and intertwined.

2.1. Issue publics

I want to start at an explicitly macro-level to think about collectives of people in terms of publics. The history of the concept is long and complex and a full discussion is beyond the scope of this text. Yet I want to focus on one of the historical approaches based on a reading of John Dewey's 'The Public and Its Problems' (Dewey, 1927) by the philosopher Marres (2005a). Dewey (1927) proposed that *"the public consists of all those who are affected by the indirect consequences of transactions, to such an extent that it is deemed necessary to have those consequences systematically cared for"* (p. 15). Rather than a singular and pre-existing public which consists of masses of individuals, Dewey proposes a series of multiple publics which emerge in response to specific issues. These publics form from people who do not necessarily know

each other but who come together around a common shared issue. In this understanding, publics arise when the official institutional apparatus does not successfully manage a controversial issue and a public needs to assemble in order to address the issue itself. These kinds of publics do not necessarily consist of huge numbers of people: their only limit is the importance of the issue, so they could perhaps be thought of as an issue pressure group. A Deweyan public *"consists of actors who are jointly implicated in an issue, but who do not belong to the same social world, so this is why they must get organised into a political community if they are to address the issue in question"* (Marres, 2005a,p. 10). Marres (2005b) describes the tight integration between publics and issues using the pithy phrase 'no issue, no public'. Crucially for Marres, issues do not spontaneously form publics. What is required is a variety of material infrastructure or 'objects of politics' (Marres, 2005a), which communicate and articulate these issues. Dewey focussed on the importance of telecommunications for organising these kinds of issue publics. Marres (2013) extends this line of reasoning to argue that these devices of public construction require a particular kind of design and are not just haphazardly given things. She argues that publics can be purposefully constructed through devices which allow people to be affected by an issue and create connections that emerge as networks. Marres (2012) does not define any particular type of technical device but describes them as enmeshing personal emotion with an issue which results in 'material publics' being formed.

2.2. Objects as actors

I am going to take a diversion into a transdisciplinary field called actor–network theory (ANT) to understand how objects acquire the power to shape our lives at an individual and collective level. ANT has evolved a rich language for thinking about people's interactions with objects and the way devices can become powerful and acquire their own agency. In ANT the key concept is the 'actor', which is used to describe humans in the sense of the human subject, as well as nonhumans such as technologies that can in certain situations function as actors. The concept of the actor describes the way that something can have an effect on the world and transform the world around itself. In this formulation of actors, ANT does not differentiate between humans and nonhumans. The best way to think about this is via a humble example given by Latour (1991) who describes how a hotel key fob functions as an actor due to its bulky form and weight. *"Customers no longer leave their room keys: instead they get rid of an unwieldy object that deforms their pockets. If they conform to the manager's wishes, it is not because they read the sign, not because they are particularly well-mannered. It is because they cannot do otherwise. They don't even think about it"* (p. 105). In this example the hotel manager does not have to talk to every guest and remind them to leave their door key at the reception when they leave the hotel. This function has been delegated to the bulky key fob. ANT suggests that objects are designed in such a way that they perform normative and even moral roles and include 'scripts' that dictate their usage. For example, seat belts are material artefacts that attempt to keep us safe in a car crash, but to fulfil this function they have to constrain people in the way they use their car. Seat belts are also legislative objects that are enforced by the state on behalf of a collective public good. ANT suggests that in our daily lives we are constantly surrounded by objects that have a variety of values inscribed into them even though we rarely think about them in moral terms. Objects are normative and have agendas which might not even be the designer's but those of a whole range of other entities and clients.

2.3. An ANT definition of size and scale

ANT offers a concept of size that is not about physical form but about association. Actor–networks are built through processes of 'enrolment' and 'translation' where one actor manages to persuade other entities to join its actor–network. The more engaging a particular situation or issue becomes, the more entities are enrolled and the larger the actor–network appears to be. All actors are themselves actor–networks and made up of smaller actors. Actor–networks are unstable and constantly at risk of collapsing back to the component parts that constitute them. For example, the social media site Facebook is often treated as a large actor and more important than a platform such as Orkut. Is this because one has a higher financial value, uses a larger number of servers or claims more users? ANT asks the researcher to *"detect how many participants are gathered in a thing to make it exist and to maintain its existence"* (Latour, 2004, p. 246). In the case of Facebook this would involve analysing a range of socio-technical elements, such as techniques for inviting 'friends', the management of media coverage and means of raising financial investment. The aim is to identify the specific ways that scale is translated and maintained which allows some actors to appear bigger than others. Callon and Latour (1981) argue that we should not take claims of size at face value: *"no actor is bigger than another except by means of a transaction (a translation) which must be examined"* (pp. 280–281). Thus ANT suggests that translations of scale do not happen by themselves, but that they require work.

2.4. Micro/macro prototyping

The tasks of enrolment and translation of scale involve the rearrangement of concepts, material objects and groups of people. I am proposing that this activity is a particular kind of socio-technical design that I am calling micro/macro prototyping. Its main mode of action is enrolling new entities in order to shift the size of an actor, this is what I call – scaling between micro and macro. This involves the building of technical prototypes that act as the locus for a gathering together networks of humans and nonhumans. This approach builds on Suchman's generative notion of the prototype as *"working artefacts; artefacts whose significance is not given in advance, but is discovered through the unfolding activity of co-operative design-in-use"* (Suchman et al., 2002, p. 172). This calls for a specific kind of relational prototype that is completed at the point of usage with people, in a context and around an issue. For Suchman the prototype is a "*performative artefact that works to align multiple, discontinuous social worlds"* (p. 175). Micro/macro prototyping uses these performative artefacts to carry out scaling. In Fig. 2, the shape on the *x*-axis represents prototypes that have been designed with deliberate values and aim at large scale normative visions. The shape on the *y*-axis represents a translation from addressing individuals towards publics. Yet micro/macro prototyping is not static but an oscillating process of scaling. It does not address stable publics because it aims to facilitate the construction of new publics.

2.5. Normative objects

This section examines how objects can be designed to confront people with normative positions which allow scaling towards larger issues. Marres (2013) calls for an experimental design practice which involve the*"deliberate investment of non-humans with moral and political capacities"* (p. 7). Critical design (Dunne, 1999) and speculative design (Sterling, 2009) harness the uncanny potential of objects to address people in affective ways and direct them towards relational positions with objects and issues. Critical design starts from a position of building 'value fictions' (Dunne,

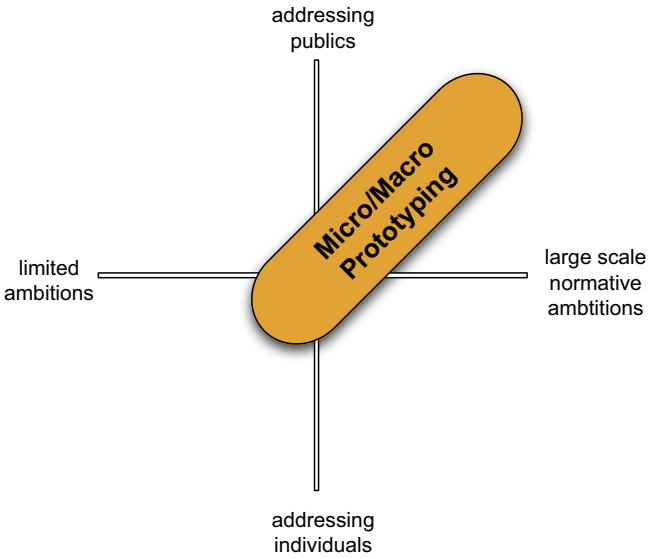

Fig. 2. Diagram positioning micro/macro prototyping as an oscillating movement between micro and macro.

1999), which embody explicit agendas and take the form of physical objects which *"force a decision onto the user, revealing how limited choices are usually hard-wired into products for us"* (Dunne and Raby, 2001, p. 46). An example is Dunne and Raby's 'Placebo Project', 2001 (Dunne and Raby, 2002) which was experimental furniture that was lent to people to place in their homes. These were highly designed and finished objects, yet their utility was not obvious or predetermined. People were asked to live with these curious objects and to reflect on the way they affected their lives. The designers focussed on documenting the sensory minutiae of participants' reactions and the unusual relationships that people formed with the objects. Rather than tool and user relationships, these objects created an ambiguous design space where objects gained a quasi-animate quality which was both unsettling and engaging. The idea was that the users would surprise themselves and become *"protagonist and co-producer of narrative experiences rather than the passive consumer of [a] product's meaning"* (Dunne and Raby, 2001, p. 46). From an ANT perspective the objects could be seen as actors that prompt the participants to position themselves in relation to the objects by either rejecting them or adopting them. If the participants are engaged by an object then they let it join their home environment. In this way the objects and participants mutually enrol each other to form an actor–network.

Sterling (2009) extends this approach with speculative design, which constructs future narratives that blend social and technological alternatives. In this approach, solid and believable design objects function as *"diegetic prototypes to suspend disbelief about change"* (Bosch, 2012, para. 3). Sterling (2009) argues *"it's not a kind of fiction. It's a kind of design. It tells worlds rather than stories"*. This approach uses the critical design object and expands it to initiate collective discussions about contentious issues such as genetic modification. I see this approach as an attempt to generate issue objects through the radical compression of issues into material objects, in which the viewer is then encouraged to re-inflate into issues. It is worth being somewhat cautious, though, of how well these objects function in terms of issue articulation and transformation. A number of commentators have expressed worries that some of this work is didactic without offering empowering solutions (Kiem, 2013; Gonzatto et al., 2013; Thackara, 2013; Prada and Oliveira, 2014). One problem is that many of the objects of critical and speculative design exist only within art gallery settings and do not become actively involved in facilitating material publics.

2.6. Design for gathering publics

There is a subgroup of designers from participatory design (PD) who use normative objects in everyday settings to gather and support publics. This design practice started in Scandinavia in the 1980s in the context of trade union-sponsored research around supporting democracy at work, which led to transformations in workplace relations through organisational and material interventions. A historical example which is interesting in terms of scaling is the 'Balao', an experimental ship built in 1972. The physical structure of the ship was changed to reduce the segregation between the sailors and officers by increasing communal areas and providing egalitarian accommodation. On an organisational level, sailors were encouraged to train in a range of positions on the ship and meetings were held to collectively allocate tasks that needed to be carried out. The idea was that this was a new experimental floating democracy within the confines of a cargo ship. Lezaun (2011) argues that the main innovation of the project was in the 'radical process of social miniaturisation', which managed to prototype a society within the confines of a ship. Interestingly the sociologists and designers who initiated the project wanted to extend the project beyond the micro-society on the ship: *"Balao was a social scientific miniature, but also a vehicle for the generation of gigantic phenomena, out of any proportion to the physical size or institutional significance of the experiment itself"* (Lezaun, 2011, p. 557). The sociologists had hoped that these experimental ships would function as demonstrative examples which would transform wider publics. Lezaun argues that the experiment did not have the hoped-for expansion effect because it organised a mini-society inside the artificial capsule of a ship, which made it difficult to translate to the wider world.

Current work in this approach is moving away from insular experiments towards being embedded in urban contexts. The Malmö Living Labs collaborate with companies, and the public and civic sector as well as local groups and individuals, in order to *"establish long-term relationships, to allow participants to become active co-creators, and to make it so that what is being designed enters their real life context"* (Björgvinsson et al., 2010, p. 42). They use an ANT understanding of infrastructure (Star and Ruhleder, 1996) as socio-technical and have turned this concept into a design method they call *infrastructuring*. Unlike the theorists I described earlier, networks are not merely studied but built, hence the addition of the '-ing' ending which turns infrastructure into a verb. The aim is to combine people and material into socio-technical infrastructure. In this design method, *"technology connects to wider systems of socio-material relation in the form of collective interweaving of people, objects and processes"* (Björgvinsson et al., 2010, p. 44). This approach has been used by a range of designers (Ehn, 2008; Dantec and DiSalvo, 2013) for whom it presents a practical way of building collectives through design practice. Dantec and DiSalvo (2013) describe this method as *"providing scaffolding for affective bonds that are necessary for the construction of publics"* (p. 260). The method is similar to critical and speculative design where *"the activities of design[…] worked to produce the objects that ultimately expressed the conditions of an issue or the desired outcome of the issue. That is, through PD, objects were created to which attachments could form. This is not to say that emotions, beliefs, or desires were shaped by design, but rather that design provided structures to which emotions, beliefs, and desires might adhere and thus be sustained"* (Dantec and DiSalvo, 2013). What infrastructuring offers is a practical and participatory way of designing around real world controversial issues. The design object becomes a way to materialise a multi-layered understanding of an issue and use it as a scaffold for people's emotions in order to gather a public.

3. Micro/macro prototyping case study

This section examines an empirical case study that uses a micro/macro prototyping approach within a real world context. The aim is to offer an ethnographic snapshot of how this approach combines an ANT concept of scale, the critical design of normative objects and the participatory design of scaffolds in order to build material publics.

The case study is part of a multi-year ethnographic research project which uses urban computing to engage with the issue of aircraft noise around Heathrow airport in London. Noise caused by aircraft taking off and landing is a highly emotive issue and there is opposition from local residents to the current level of noise as well as the proposed expansion of the airport. This opposition extends to the political level where the airport expansion is seen as a national election-winning or losing topic. Aircraft noise is a highly technical issue involving complex models which try to predict the exposure for the area and inform the regulatory procedures of the airport. According to the institutions creating the models, the level of noise exposure is highly predictable with a minuscule margin of error. Yet many of the local residents I came into contact with feel they are being lied to and systematically marginalised by these institutional monitoring procedures. The residents are a diverse group that includes many that are well-informed about the legislation of noise and regulation procedures of the airport. A significant number of residents are interested in carrying out their own noise monitoring to collect evidence and put pressure on political representatives. Some are very technically able and interested in designing their own monitoring equipment.

3.1. Designing for a socio-technical context

How can one design for this mix of technologies, legislation, expertise, opinions and experience? A technical—micro-approach might be to design more detailed noise models, while a macro-approach might focus on survey methods that capture people's experiences in a more granular way. My argument is that the problem of noise is precisely the compartmentalisation between micro and macro, technical and social. We can see this via the example of the *'Schultz curve'* (Schultz, 1978) which tries to establish a correlation between decibel dosage and universal community annoyance. Variations of this curve have become enshrined in noise regulation as universal predictors of community annoyance. Yet acousticians such as Fidell (2003) argue that the *'Schultz curve'* is actually a highly unsuitable metric since *"decisions about the award of billions of dollars of federal subsidies to construct airport and highway infrastructure […] ostensibly rest on the shape of a purely descriptive fitting function, unsupported by quantitative, theory-based, or other systematic understanding of the origins and mechanisms of community reaction to transportation noise"* (pp. 3009–3010). Instead Fidell proposes empirical approaches based on spontaneous self-reporting by residents of their complaints. These would be enabled by computing which allows for geolocation and visualisation (Fidell, 2003, p. 3013). I suggest that this shift towards systems that interweave people and technology is an acknowledgement that community noise is socio-technical and not just an engineering problem. This means that this topic is a rich area for urban computing to explore with experimental prototypes that reshape the boundaries of what is technical and social.

3.2. The prototypes in a workshop setting

The researcher/designer's goal in the case study was twofold. The first was to understand how micro/macro prototyping might be able to engage with local residents to understand the existing framings of noise as technical, experiential and political. The second goal was to start a process of infrastructuring and co-designing a range of tools to support a new material public around noise.

I designed four prototypes based on my observations of the way the issue was being framed by residents and other spokes-people in Heathrow. Each of the prototypes is a physical object as well as a hypothesis, or more specifically a proposition – a normative articulation of how the noise issue should be handled. The aim of the prototypes is to be provocative and not necessarily to seek the participants' approval of the designs. Rather like critical design, the goal is to trigger responses from the participants and open up the framings of noise for both the researcher and participants. The values that the prototypes embody do not necessarily reflect my own but are a distillation of existing discussions.

Each of the devices has a name which summarises the propositions: 'I speak your feelings', 'I display noise publicly', 'I make someone responsible', 'I turn noise into numbers'. Naming the devices in this way reinforces the idea that each one is a unique actor with its own distinct position. The prototypes were made in a short timeframe, so the physical finish is not as refined as that of critical design objects which are created for art galleries. Instead the designs were intended as an iterative part of a continuing process of engagement with a local group of people. The requirement was for the prototypes to function technically and conceptually in order to connect tangibly and emotionally with the participants and confront them with the propositions.

The following vignette describes the workshop in which the prototype devices were used by nine local residents from Isleworth. The participants did not know each other and were invited to attend the workshop via a pressure organisation which opposes the expansion of the airport. The workshop was held at a local community centre which is positioned under the flight path. This meant that during the 2.5-h workshop, aeroplanes could be heard overhead at regular intervals. While the noise level was not enough to disrupt conversation, it created a material reminder of the issue that was being addressed.

3.3. Prototype: 'I speak your feelings'

The prototype in Fig. 3 consists of an Arduino micro-controller, an electret microphone, an amplification circuit and an LCD screen. The device continuously samples the voltage sensed by the microphone and translates this as text to the LCD screen. Instead of decibel numbers, the screen displays the current sound

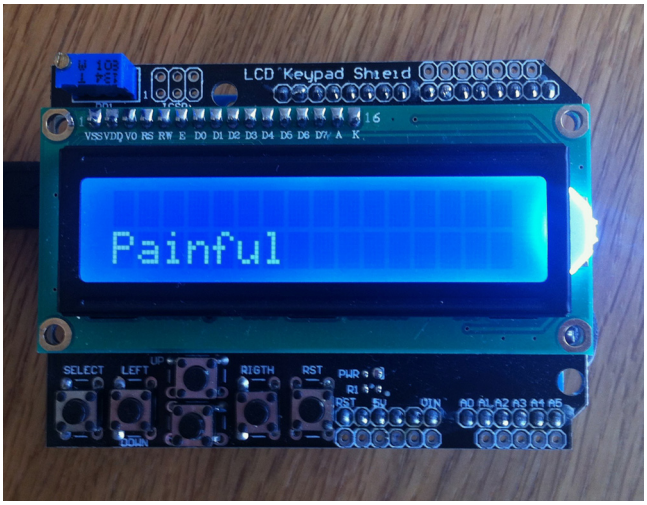

Fig. 3. Photo of the 'I speak your feelings' prototype.

Fig. 4. The 'I display noise publicly' prototype as an image mockup.

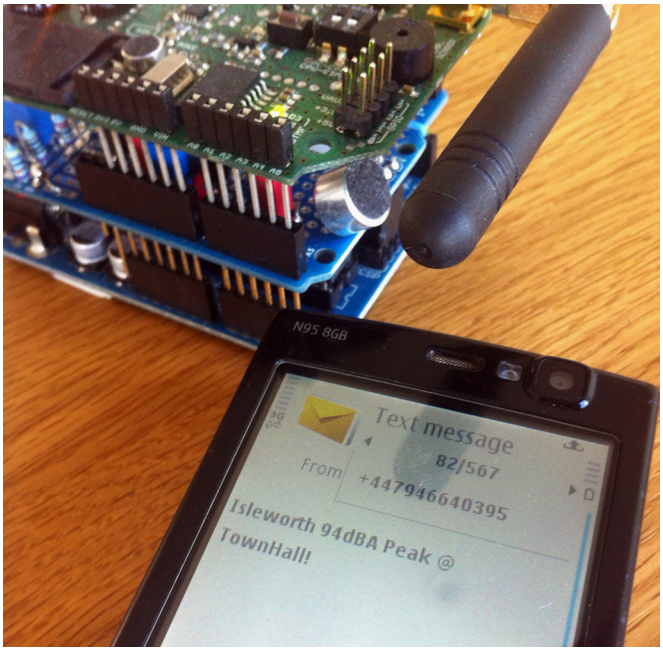

Fig. 5. Photo of the 'I make someone responsible' prototype.

situation using a scale of emotive words: silent, quiet, audible, loud, very loud, extremely loud and painful.

The prototype is based on the observation that institutions frame noise as technical and measurable, while many local residents use a highly emotive language to describe their own experiences. Both these framings coexist in the public dialogue, yet they do not seem to be directly comparable and operate in their own domains. The proposition of the prototype is to bring them together in the form of a machine that talks in emotive and experiential terms on behalf of humans. The aim is to uncover possible design directions for future devices in terms of how they should relate to existing languages for talking about noise.

When the device was presented to the group the reactions were very diverse. Some of the participants used the prototype as a catalyst to talk about the way noise affected them without referring to decibel numbers. These participants identified a range of factors that influenced their experiences including noise frequency, personal tiredness as well as differences between mechanical and human noise. One participant summed up the discussion with *"it's not just decibels, there is something else in there as well"*. Yet interestingly the prototype had an antagonising effect on two of the participants who found the device highly frustrating. One of them said, *"I think it would be completely chaotic if you just had people's feelings about it[noise]. What would you do with that data? You have got to have an objective reference"*. Before the prototype was introduced, the group had been cohesive and there had been little disagreement. Yet once the prototype was demonstrated, the group quickly divided over the importance of an objective metric. Those participants who felt engaged by the idea of an alternative language for noise were intrigued by the device and chose to think with and beyond the function of the prototype, and suggested other ways a technology could talk about experience such as measuring physiological stress in the body. The oddness of the device seemed to give these participants the liberty to talk about their experiences in an open and revealing way that included subtle descriptions of how noise acted on their daily lives. For me the discussion suggested that measurement should be an important part of any future prototype. Yet there seems to be a conceptual space for measuring noise using alternative means and metrics such as physiological stress or other environmental indicators.

3.4. Prototype: 'I display noise publicly'

The prototype in Fig. 4 consists of a visual mockup of a large noise meter and display mounted on the outside of a local building in Isleworth. The image was printed as an A3 colour photograph and given to each participant to look at. I explained that the device would flash brightly when a specified noise level was exceeded.

The prototype is based on two notions. The first is my observation that the housing under the flightpath looks like any other suburban area, and that there are no visible references like posters or public signs to the noise problem overhead. The second is the idea that noise should be a communal issue of concern rather than a problem faced by individuals. The proposition of the prototype is to materialise noise as an object in public space. It is designed to spark debate among the residents and encourage them to join a pressure group. The prototype is intended to prompt tactical questions of how to raise the issue locally and engage more residents.

During the workshop, I introduced the prototype as something that could be mounted on the participants' houses and might be a way to engage their neighbours. In the discussion it quickly emerged that they were not keen to fix the device on their home. Instead they suggested that it should become a 'norm' to have it installed on public buildings including offices and schools in the area. One of the participants stated that there could be negative consequences to mounting it on one's own house: *"I don't want to be a downer on this, but we do have to bear in mind that people think that campaigning and emphasising the noise problem - is giving them a problem. Because it affects the value of their house and they might be wanting to sell their house and they don't want to be labeled as a problem area. And we have found that schools have quite remarkably low levels of interest because they get money out of the airport for various activities and they don't want to be seen as the wrong school to send your child to"*. After the participant had said this, a number of others nodded and voiced agreement. It appears that the prototype made the participants uncomfortable since it would publicly identify them as trouble-makers. Rather than generating local solidarity, the prototype was perceived as potentially victimising individuals or institutions that were speaking up about noise.

While the prototype was not popular, it was successful in opening up the complex micro/macro-dynamics of the issue and clarifying the ambiguous position that local people and organisations found themselves in. There appears to be a lot of pressure to

leave noise to be managed by institutions rather than allowing concerned residents to do something about it themselves. Rather than just affecting individuals, the noise dynamic is shaping collective behaviour by introducing coercive expectations about how local people are supposed to respond.

3.5. Prototype: 'I make someone responsible'

The prototype in Fig. 5 consists of an Arduino micro-controller, an electret microphone, an amplification circuit and a GSM mobile phone module. The device is set to send a pre-formatted SMS text to a mobile phone whenever a decibel level of 90 dB(a) is exceeded.

The prototype is based on previous conversations with residents where I sensed a lack of clarity about who or what was responsible for the local noise pollution. During the discussions a whole range of entities were blamed from local and national politics, government agencies, the airport, individual airlines as well as capitalism in general. The provocation of the prototype is to force the participants to choose a single individual who is held directly responsible. The aim of the device is to obliquely ask about strategic goals and methods for a resident based noise monitoring project.

When I introduced the prototype I showed the group the source code of the micro-controller and mentioned that the mobile number in the code could be changed to any phone number. A dramatic transformation in the atmosphere occurred, with all the participants suddenly laughing loudly, as they understood the implication of inserting somebody else's number into the code. The participants excitedly discussed a range of potential entities that could have their phone number inserted into the source code. The potential candidates ranged from airport complaint lines, institutional bodies, local politicians in favour of airport expansion, national politicians as well as the prime minister himself. While a whole range of people were discussed, there was no consensus regarding who could be held directly accountable. What was interesting was that some participants in the group were keen on the confrontational approach of the prototype, while others felt the targeted text messages were too personal and wanted to make it more public by redirecting the messages to Twitter or automated hotlines. One participant said, *"I think tweeting may well be a more acceptable way of doing that and it's in the public domain so you can see there have been 80 tweets at that time in the morning and it's not going to a direct person"*. In contrast another participant extended the logic of the prototype by talking about mounting loudspeakers outside a politician's house to wake them up when the flight noise starts at 4:30 in the morning.

The most interesting aspect of the prototype was the way its directness and antagonistic proposition triggered a strong emotional response from the participants. Throughout the workshop the participants focussed their discussions and visual attention on the function of the prototype. Whenever voices were raised or a plane flew overhead, the device would send a SMS message which would be received with loud bleeps and the group would respond with laughter. This prototype proved to be the most interactive and performative. It allowed the participants to scale from the micro-context of the device towards the possible political impact as it sent a continuous stream of text messages to a remote representative. The prototype directly connected grassroots noise monitoring with a political actor by cutting out the institutional middlemen. The diverse range of reactions by the participants shows that any device designed to support this group cannot adopt a pure form of address but has to capture and materialise the diversity of participant positions.

3.6. Prototype: 'I turn noise into numbers'

This prototype consists of an Arduino micro-controller, an electret microphone, an amplification circuit and an ethernet connection. The device uploads the measured sound pressure at regular intervals to an online repository where it is presented visually as a time series. The noise pattern of aircraft can be clearly identified as spikes on the online graph.

This prototype is the result of direct requests by residents for a static monitoring device that could be placed in their own home and used to provide evidence of their noise exposure. The device accepts the technical and institutional paradigm that noise can be measured by a microphone. The innovative proposition is to change *where* and *how* those measurements are taken as well as *who* is doing the measuring. The device is designed to be assembled and maintained by the residents themselves, thereby putting them in charge of collecting evidence of their own exposure.

During the workshop, this prototype triggered the least discussion and provoked no disagreement among the group. The residents asked me questions about where it could be located in their house and whether future versions could adopt more sophisticated hardware for higher accuracy. The innovation of the prototype was its low cost and potential accuracy, which could allow a large network of local sensors to be set up to gather evidence for the group. Yet as a conceptual level, the prototype was not very innovative and seemed to be familiar to the participants. The prototype was treated more as a tool that could be used, rather than a provocation that needed to be discussed. At the end of the workshop when I offered to lend all the prototypes to the participants, half of the group immediately asked to set up this prototype in their house.

3.7. Analysis of the case study

The activity with the prototypes took place towards the end of a larger workshop in which other sound monitoring tools had already been discussed. This meant that the impact of the prototypes could be compared with the discussion that had already taken place. The prototypes seemed to have a dramatic effect on the level of enthusiasm in the discussion with an increase in scope and complexity of topics. Each of the four prototypes communicated their own proposition and the participants were highly engaged and tended to expand beyond the functions of the devices. Yet the prototypes required facilitation. It was not enough to simply unveil the prototypes and step back. The devices required verbal introduction to describe their function, a physical demonstration and some limited coordination of the resulting conversations. The prototypes functioned by providing a performative focus, but the researcher/designer was still involved in the infrastructuring process which required alertness and enthusiasm.

There was a broad range of reactions to the prototypes, ranging from surprise and irritation to entertainment. Rather than creating a consensus, the prototypes created a kind of good-humoured 'dissensus'. The idea that disagreement is a productive and essential part of democracy has been made by Mouffe (2000) and extended into critical and participatory design by Disalvo (2010) who argues that the goal of design should be to facilitate agonistic spaces where disagreement can be voiced to open up new themes and trajectories for action. The atmosphere in the workshop was not hostile but rather a targeted critical discussion on the best tactics and strategies for a community noise monitoring process. The prototypes acted as provocation pieces which allowed a group of people who had not previously met to enter into deep, personal and political discussions. From a participatory design perspective *"constituting a public involves discovering and*

expressing the attachments of a particular group. Infrastructuring, as an activity of PD, is the work, then, of providing the means for discovering and expressing those attachments in order to convey the consequences of an issue and to enroll others in a cause" (Dantec and DiSalvo, 2013, p. 255).

From my perspective as an ethnographic researcher having worked in the Heathrow context for a year, the workshop uncovered local dynamics that I was not aware of and would have found difficult to articulate as verbal questions. The activity identified the ambiguous relationship the local residents have with institutions. The main insight was the radical rhetorical translations of scale and topic within the noise issue which ranged from electronic components, people's experience of being woken by planes, schools scared to take public positions and the disengagement of politicians. The fluidity with which micro and macro were transversed and often collapsed is a key observation at the workshop. The prototypes did not create a unidirectional shift towards the macro-level of politics, economics or 'the people' but instead allowed the residents to uncover the noise issue as bouncing across scales without coming to rest in any particular register. Using the insights of ANT, the issue of noise is unstable and performative and shifts scale in relation to the particular viewpoint used to look at the issue. The noise issue can appear large and insurmountable when one maps all the different institutional actors that have been gathered together and yet can appear small and manageable when one examines electronic sensors.

It is here that I see the main benefit of using 'issue devices' to discuss noise as a 'device issue'. The materiality of the prototypes allowed the noise discussion to have a material basis which enabled the micro/macro-scaling to take place during the workshop. It is this specificity in relation to a contentious issue which extends critical and speculative design approaches. Instead of fantastical future visions, the micro/macro prototypes offer tangible alternatives which change the size of the noise issue by adding new actors or removing existing ones. The effect of presenting a range of four different devices meant a variety of propositions could be explored, from the conceptual towards the immediately practical. The workshop was productive in suggesting future devices which could be based on diverse and perhaps even antagonistic understandings of noise – within a single device. The workshop also provides a warning for design methods which approach this kind of situation with a view to simplistic problem solving. Carrying out technical interventions into such a complex context could have highly unpredictable consequences.

Finally the workshop set in motion the building of a noise monitoring group. After the workshop a number of participants emailed me about installing one of the 'I turn noise into numbers' prototypes in their own home. This resulted in one device being installed at one of the participants' homes for a period of several months. The data generated was of such interest that somebody who was not the prototype's owner informed me when the device temporarily stopped working. Since then I have created a mailing list and held another workshop, which included people who wanted to build the next iteration of the device and have it set up in their home. This group includes technical developers, a sound artist, a researcher working on the impact of noise on biodiversity, as well as participants from the original workshop. The current prototype is loosely based on 'I turn noise into numbers' and uses a Raspberry Pi computer with a USB microphone, which allows higher accuracy sound measurements that relate better to the official measurements. In addition the device creates a live audio stream of aircraft flights which people can listen to on the internet. The eventual goal is for a map interface that geolocates the devices and allows website visitors to listen to the plane noise inside people's homes. This setup will hopefully give listeners a tangible and affective experience of the noise issue which will accompany the statistical data being gathered. This iteration of the device is based on feedback from the initial workshop as well as discussions with the pressure organisation who want to draw attention to the impact of the airport on the whole of London. Being able to demonstrate that aircraft noise occurs outside of the demarcated noise exposure area will allow the organisation to create a new public framing of the noise issue. The case study is ongoing and will hopefully lead to the deployment of dozens of devices around Heathrow and the building of a new material public.

4. Conclusions

This paper started by identifying the gap between the micro and macro of urban computing in terms of normative ambition and audience. It proposed that the gap might be addressed via a transdisciplinary approach that combines theory and practice via scaling. I examined ANT, which does not accept size as a given but sees it as a result of enrolling large numbers of entities into networks. This gathering is a kind of persuasion through physical and semiotic design, which if successful can make something appear big. In this way ANT provides us with a model of the designer as a scale shifter. By creating devices with the concept of socio-technical scaling in mind, designers can engage new actors and construct material publics. Critical and speculative design proposes normative objects that have the power to engage at a profound emotional level and propose alternative futures. Taking this approach into a participatory setting creates the notion of infrastructuring and the design object as a scaffold that supports the coming together of things, people and issues as material publics. I feel this approach offers two important opportunities and challenges in terms of the scope of urban computing and the role of the designer.

The first opportunity involves the expansion of the remit and scope of urban computing. I propose that we can permanently fuse place, technology, and people by designing through the lens of contentious issues. By starting from an issue such as community noise, the technical and social, practical and theoretical, micro and macro are all simultaneously vying for our attention. Engaging and acknowledging this multiplicity allow the range of actors involved in an issue to be treated as clients. In this way design can do more than reinterpret and represent. Socio-technical designs such as the community monitoring project have the potential to gather existing actors to form new actor–networks that re-shape an issue. The local dynamics of Heathrow might be forced to change due to the arrival of this large actor, which can potentially transform the operations of the airport. The main opportunity and challenge of this design approach is that it acknowledges and supports the complex role that design objects play in social and political processes. I am not suggesting that this approach is appropriate for all urban computing problems. After all, this approach has not been used to build any large scale infrastructure such as a smart city control system. Yet if one is open to alternative approaches of managing traffic, such as experimenting with the removal of traffic lights (Baker, 2009), then micro/macro prototyping can be a valuable tool even for such technical problems.

The second opportunity is one of changing the role of the designer. In this vision the designer functions as a scale shifter to actively engage with an issue at multiple scales and transform it at these different levels. That means the designer needs to let themselves be pulled along by issues into unfamiliar contexts and disciplines. The role of the designer is not just to create devices but to become part of the network they are building. As we saw in the case study, the prototypes do not stand outside of the

designer, but are part of their infrastructuring of a material public. Björgvinsson et al. (2012) describe design as *"facilitating the careful building of arenas consisting of heterogeneous participants, legitimising those marginalised, maintaining network constellations, and leaving behind repertoires of how to organise socio-materially"* (p. 143). This design approach involves a personal and ethical responsibility towards the kinds of scaling that is carried out and the devices and publics that are being constructed. The potential of the micro/macro prototyping approach is that it envisages urban computing as a truly transdisciplinary practice that allows issues to be followed and engaged with, and their dynamics to be redesigned across different scales.

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