Power to the People: Hacking the City with Plug-In Interfaces for Community Engagement

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Abstract This chapter presents a discussion about the design and development of bespoke "city hacking" initiatives focused on community engagement. We draw from the literature in the field to propose a definition of *plug-in interfaces* as portable interactive technology deployed directly to public spaces on a temporary basis and addressing pre-existing architectural and social affordances. We then present a series of short-term cross-sectional field studies where we make use of two distinct plug-in interfaces to contrast different design scenarios against three core contextual constraints: (1) *technology familiarity* of the interfaces; (2) *level of integration* of the interfaces into the built environment; and (3) nature of *pedestrian activity* ordinarily unfolding in the urban precinct. We then discuss the observations from the studies and derive some initial findings regarding the utilisation of plug-in interfaces as tools for city hacking with the purpose of developing community engagement campaigns with rapid deployment and quick turnaround.

Keywords Urban interaction design · Urban interfaces · Smart cities
Community engagement

1 Introduction

This chapter presents findings from a city hacking initiative focused on community engagement. It is structured as a series of short-term cross-sectional field studies evaluating the effectiveness of placing tangible user interfaces in public thoroughfares for the purposes of public consultation on local community matters.

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Community engagement initiatives provide public venues for citizens to partake on decisions affecting their immediate environment (Gianluca et al. 2013), allowing local governments to take actions informed by public opinion and aligned with the community concerns (International Association for Public Participation Australasia 2009). However, face-to-face meetings, online surveys and other traditional methods of consultation are often disconnected from the social-cultural context (Fredericks and Foth 2013; Gianluca et al. 2013; Schroeter et al. 2012; Valkanova et al. 2014) or not easily accessible. Consequently, they often fail to reach representative proportions of the public.

In order to overcome those barriers to civic engagement, various initiatives (Behrens et al. 2014; Mueller et al. 2012; Schroeter et al. 2012; Taylor et al. 2012) have been proposed for situating digital polling interfaces directly in public spaces, therefore lowering the entry barrier. However, a common observation from those studies is that passers-by often do not notice the interfaces (Fredericks and Foth 2013; Gianluca et al. 2013; Taylor et al. 2012), which leads to low levels of participation. Recent research has demonstrated that the effectiveness of digital interventions in public spaces is highly determined by constraints imposed by the local context (Behrens et al. 2014; Hespanhol and Tomitsch 2014), including the type of digital media devices used, how familiar they are to general members of the public, how integrated they are to the physical built environment, their level of distribution across the urban precinct, how the digital interfaces are introduced to passers-by as they walk through the public space, how many people can simultaneously interact with them at any given time, the type of feedback provided, and so on. To that end, we propose the utilisation of low-cost portable interactive technologies deployed directly to public spaces on a temporary basis—as a platform to investigate three common contextual constraints (Hespanhol and Tomitsch 2015): (1) *technology familiarity* of the interface; (2) *level of integration* of the interface into the built environment; and (3) nature of *pedestrian activity* ordinarily unfolding in the urban precinct. Furthermore, we propose the notion of *plug-in interfaces*—motivated, in turn, by architectural and social affordances offered by the public space and resulting in temporary choreographies of interaction—as a method for hacking the city to design lightweight community engagement initiatives.

To address the first aspect, we implemented two interfaces: (I1) an iPad running a traditional online survey; (I2) a portable ready-made device using audio to ask "yes/no" type questions to passers-by, who could cast their votes by placing their hands on top of sensors embedded in the device. By using those two interfaces, we sought to compare the effects of technology familiarity versus the placement of devices as unfamiliar urban furniture. For testing the level of integration of the interfaces into the built environment, we deployed each of them in two configurations: (C1) attached to a street pole next to where people walked; (C2) mounted on a portable stand, placed on the sides of the thoroughfare. Finally, for gauging the impact caused by the nature of pedestrian activity, we adopted two different locations for running the studies: (L1) pedestrian crossing controlled by traffic lights; (L2) fully pedestrianised thoroughfare.

We ran a total of eight field studies testing all combinations of the above variables. In each study, we observed conversion rates and the behaviour of passers-by in regard to noticeability and discoverability of the interfaces. From the observations gathered, we then derived initial insights regarding motivational factors for impromptu interaction and intuitiveness of the interfaces. We discuss the issues commonly faced by city hacking deployments for community engagement, as well as considerations about the validity of the observed public participation. We conclude by pointing out strategies for effectively employing plug-in interfaces as lightweight tools for similar bottom-up initiatives.

2 Background

Community engagement is an administrative strategy commonly used by governments and research organisations to learn about the views, opinions and ideas of local residents of a neighbourhood. Traditionally, they have taken the form of exhibitions about new development proposals, followed by public sessions held at town halls, where citizens gather to deliberate directly with the local authorities, voice their concerns and vote on possible outcome options based on their preferences. Yet, local government authorities themselves have started to acknowledge shortcomings on traditional civic participation initiatives (Fredericks and Foth 2013; Gianluca et al. 2013; Schroeter et al. 2012; Valkanova et al. 2014). For example, many people may not be aware of the community meetings and their schedules, or simply may not be able to attend them. Some individuals may also avoid fear of public embarrassment, feeling discouraged to express their opinions in front of others, especially if those defy the views of the majority. The use of online surveys for gathering feedback from local communities on development proposals addresses some of these aspects but also introduces participation barriers, as people need to discover and be able to access the online platform and have to make time to complete the surveys (Fredericks and Foth 2013). The view that individual public spaces and communities have individual requirements has encouraged the design and development of bespoke technologies to engage specific sections of the communities directly within the public spaces they use and provide a platform that appeals more directly to the patterns and concerns of their daily life (Taylor et al. 2012). Interaction designers and urban planners have increasingly grown aware of the fact that the design of interfaces for community engagement is strongly shaped by the physical, social and cultural contexts of the urban public space in which they are deployed (Behrens et al. 2014; Bilandzic and Venable 2011; Hespanhol and Tomitsch 2015). Those factors, of course, may significantly shift overtime, and awareness of this shift has led to more lightweight urban interventions, "hacking" various elements of an urban precinct by appropriating and augmenting them for a short period of time and with a purpose often unrelated to their original role in the public space. Caldwell and Foth (2014) investigated the emergent attempts to articulate placemaking specifically with digital media and interactive technologies through grassroots approaches generally referred to as "do-it-yourself"

Table 1 Theoretical angles informing plug-in interfaces

Theoretical angles		Design options
TA1	Contextualisation	Private and semi-public indoor spaces Public plazas Public thoroughfares
TA2	Agency and accountability	Top-down Bottom-up
TA3	Aesthetics of public interaction	Media modalities Placement Spatial layout Feedback strategies

(DIY) media architecture. Such a DIY mindset, coupled with the increasing affordability and availability of Web, tracking and social technologies, has also prompted numerous other instances of grassroots activism (Koeman et al. 2015; Kuznetsov et al. 2011; Vlachokyriakos et al. 2014), where the urban environment is temporarily hacked by its own citizens. Admittedly, in some of those instances, the city hacking interventions are actually designed by academic researchers, with the goal of creating new platforms through which citizens could eventually take over and participate in. Nevertheless, this trend reveals a shift in agency and accountability regarding civic participation, from a traditionally top-down agenda driven by government and occasionally consulted with people, to an emerging bottom-up movement rooted on self-organisation. Notably, this movement works actively towards persuading the authorities about new community solutions informed by peer feedback at the citizen level and supported by rapid urban prototyping carried out directly in public spaces.

In that regard, Matsuda (2010) also identified a similar turning point in broader social relations, observing an increasing appropriation of the public space for activities previously confined to private or semi-private environments, and pointing to a fundamental shift in individual forms of expression towards shared spaces, a trend he referred to as *augmented domesticity*. Digital technology has enabled experiential privacy in public spaces by offering instant and ubiquitous availability to personal data while providing acceptable levels of access control. Echoing Hill's (Hill 2008, 2010) realisation of the city as a platform—or "soft city"—Matsuda argued that the physical qualities of an urban space have become less relevant than its role as a platform for technology-driven social interactions:

> As the public and private spheres established in the 19th century merge, and space is perceived differently by each person, this terminology [private/public space] can no longer express universal spatial qualities. (source)

Based on the points above, we can therefore articulate the use of public space for community engagement from three different—yet related—theoretical angles (Table 1).

The first informs the themes of engagement and participation from a socio-political perspective, particularly the attempts at *contextualisation* (TA1), referring to the

curated choice of specific public spaces for the deployment of lightweight community engagement urban interventions [e.g. plazas versus thoroughfares, as defined by Hespanhol and Dalsgaard (2015)]. The second angle relates to levels of *agency and accountability* (TA2) prompted by different mechanisms of top-down (government bodies) or bottom-up (citizens, community groups and design researchers) appropriation of public space for the purposes of community engagement. And the third angle relates to what we refer to as the *aesthetics of public interaction* (TA3), more specifically relating to the design aspects (media modalities, placement, spatial layout, feedback strategies, etc.) relevant to choreographing community engagement and placemaking. In this chapter, we attempt to use those three theoretical angles to inform our research in regard to investigating the utilisation of *plug-in interfaces*—portable interactive technology deployed directly to public spaces on a temporary basis—for the purposes of community engagement. As we will discuss in the next section, this is not an entirely novel concept, rather a direct consequence of the city hacking ethos born out of the above-mentioned bottom-up activism boosted by digital technology. Yet, definition and understanding of plug-in interfaces as a *design strategy* on its own right—particularly for the purposes of urban prototyping (Hoggenmüller and Wiethoff 2014; Korsgaard and Brynskov 2014)—is still largely lacking. To the extent permitted by the scope of this chapter, we propose a definition of plug-in interfaces and present a series of short-term cross-sectional field studies where we contrast different design scenarios against specific contextual constraints. Further, we present initial findings regarding the utilisation of plug-in interfaces as a tool for community engagement campaigns supporting rapid deployment and quick turnaround times.

3 Plug-In Interfaces

In the 1960s, the British avant-garde architectural group Archigram conceived Plug-In City, a futuristic concept for dynamic city planning (Sadler 2005). Plug-In City consisted of a central scaffolding framework spanning a very extensive area, where moveable modular residential and commercial units could be attached to, moved around or removed according to local urban planning and design requirements. Transportation, sanitation, computing and other essential services would be embedded into the central infrastructure and shared by the community but designed in a way that would allow them to be readily reallocated to other parts of the city, if necessary. By allowing a temporary and flexible deployment of urban resources, Plug-In City would enable adaptable collective living, integration of transportation and the accommodation of rapid change in the urban environment (Merin 2013). Despite its clearly utopian character, Plug-In City helped to forge a vision for a more agile, readily adaptable deployment of specific resources for well-defined purposes within the urban environment. By keeping the scope of the plug-in modules smaller, design solutions could not only become more realistic, but also their implementation less

risky—if a newly tried module failed its intended purposes, consequences would be less damaging, and reversing the change much easier and less costly.

The concept of *plug-in modules* has also been borrowed by information technology and extensively used since the 1990s in the design of software applications. Typically, plug-in modules consist of third-party software components that can be installed as extensions to existing applications, expanding their scope of features. Plug-in releases represent an extremely common platform for allowing controlled addition of features by independent developers to well-established applications such as Web browsers (Google 2015; Mozilla Foundation 2015), content management systems (Wordpress.org 2015) or integrated development environments (Vogel 2015).

Recently, concepts reminiscent of Archigram's Plug-In City have materialised both in specific niches of architectural designs as well as in the form of digital furniture in public spaces. Shipping containers, for example, have been used as temporary dwelling units, movable hotels or structures for pop-up community markets (Williams 2015). Due to their resilience and portability, they have also become a popular temporary housing option in Christchurch, New Zealand, following a 6.3-magnitude earthquake that hit the city in 2011 (The Press 2014). Likewise, small-scale digital devices extending the built environment for purposes of public consultation or tracking have become increasingly common, such as digital customer polling interfaces (Fig. 1). Plug-in initiatives are particularly well suited for grassroots, placemaking activities, for allowing the quick trial of new layers of public infrastructure that manage to fit—spatially as well as functionally—into perceived "urban gaps" resulting from vacant or underutilised sections of the city. More importantly, those added layers can be completely and seamlessly uninstalled after the event, without loss of features from the original design. PARK(ing) Day and Build A Better Block (Lydon 2012) are relevant examples of such grassroots plug-in initiatives.[1] Examples exist where, upon community endorsement on the outcomes of those initiatives, local governments approve their deployments as permanent new urban features—as is the case of the "parklets" installed at the Civic Centre in Canberra, Australia, illustrated in Fig. 2.

We can observe, therefore, a degree of interdependency between system and interface, whereby the plug-in character of the latter is a consequence of it fitting into the social and architectural affordances of the former. In that sense, plug-in interfaces represent more than just a temporary—or "pop-up"—feature added to an urban space: just like in Archigram's *Plug-In City*, they consist both of *systemic* factors—represented by an urban architecture designed with qualities that support (intentionally or not) appropriation by external agents—as well as *usability* factors—represented by the resulting urban interfaces, the mechanisms guiding their uptake by the community and the orchestration of the interactions with them by the various social actors involved. This is true regardless of whether the plug-in interface is designed as a physical, digital or hybrid addition to the built environment.

[1]PARK(ing) Day is an internationally recognised event where parking spots in various cities and towns are transformed into pocket parks and parklets. See for instance https://www.civicdesigncenter.org/events/parking-day.

Fig. 1 Customer polling interface at Aarhus Airport, Denmark

In this chapter, we focus on plug-in interfaces that incorporate digital media. To that extent, examples of systemic factors include public infrastructure where sensors or devices can be temporarily installed at (such as poles, trees, fences and benches), provision of electrical power or Wi-Fi connectivity within an urban site, or even spatial affordances such as a wider sidewalk, an atrium, a lobby or unused corners of a plaza. Conversely, usability factors include the type of media device used to construct the interface, the kind of sensing mechanisms employed, how feedback is given to users, how many users can interact simultaneously, how discoverable and intuitive the interface is, the time taken to answer the questions asked, and how publicly or privately the interaction unfolds in the shared public space.

Following on from the concepts above, we therefore define *plug-in interfaces* as portable, interactive media technology, deployed directly to public spaces on a temporary basis and leveraging on existing urban infrastructure and social dynamics. Conversely, we define (a) *plug-in architecture* as the set of design properties observed in or assigned to a built environment that enables the accommodation of plug-in interfaces; and (b) *plug-in choreography* as the set of new social dynamics unfolding in the public space as a consequence of the deployment of a plug-in interface. The design and implementation of plug-in interfaces tap into the ethos of the Internet culture and agile practices (Silberberg et al. 2013; Urbagram 2011) to promote human-centred, participatory design of public spaces, whose features emerge

Fig. 2 Permanent parklets in Canberra, Australia

from its own live social dynamics through a low-risk iterative process that embraces change and swiftly adapts.

The notion of plug-in interfaces is, therefore, largely formal, in the sense that it is characterised by the spatial affordances of the public space architecture and the social dynamics of its target urban precinct, regardless of its actual purpose or content. However, it is precisely its property of being at the same time bespoke and hyper-local, yet easily adaptable and ultimately reversible, that makes it highly suitable for city hacking community engagement. As discussed above, community engagement and, more broadly, placemaking initiatives have typically been realised via top-down public consultation, following an agenda driven by the government. More recently, local government authorities have also resorted to lightweight urban interventions—often in the form of "pop-up" events (Fredericks et al. 2015, 2016)—in an effort to reach out to communities, especially citizens otherwise alienated by the traditional political process. Given their temporary deployment in public spaces, those government initiatives could arguably also employ plug-in interfaces and rapid prototyping as a design strategy—and, in fact, the insights from this article are also applicable to them. However, their agenda is still admittedly top-down in the sense that the questions asked and the data gathered are still under the control of a representative body. It is precisely the ability of plug-in interfaces to allow regular citizens also to "attach" temporary, lightweight digital media interfaces directly

into "suitable" sections of the built environment that makes them such a powerful tool for city hacking. In doing so, ordinary people can appropriate sections of the public urban space, while retaining agency and accountability over the consultation process with a relatively low budget. They can also subvert them for a controlled and temporary manifestation of urban activism, reversible by nature and limited in duration. By bringing rapid prototyping and continuous improvement into the urban planning field, plug-in interfaces promote an iterative approach to placemaking through direct consultation with the general public as well as with stakeholders—such as urban planners, local governments, urban interaction designers and community members. In the process, they also enable stakeholders to fail early, fail often, welcome community input in the elaboration and test of urban interventions, and attain continuous improvement from iterations of rapid prototyping.

Although, plug-in interfaces as a design strategy for urban prototyping and community engagement have not been previously formalised, numerous recent studies have started to trial plug-in interfaces as design solutions. In those studies, the researchers often assume the role of regular citizens and probe the ability of the designed plug-in interfaces to enable bottom-up and middle-out (Costa and Ferrão 2010; Fredericks et al. 2016) approaches to community engagement. Vlachokyriakos et al. (2014) adopted the principles of DIY Media Architecture to conceive *PosterVote*, a low-cost electronic voting system for conducting public surveys. The system is designed as an open-sourced kit consisting of two components: (a) a lightweight hardware set of buttons and LEDs; and (b) a paper poster placed on top of the hardware module and displaying questions to the community. People can then answer the questions by pressing the buttons, receiving some limited feedback on the interactive process from the LEDs. *PosterVote* is a plug-in interface for making temporary use of the affordances offered by public furniture—such as electrical poles, fences and walls—where the posters can be easily hung from or attached to, but later also swiftly removed without leaving traces. Given its low cost and portability, *PosterVote* makes an ideal platform for grassroots activism and can be easily distributed across a public space, allowing both dispersed and in situ social action.

The *Viewpoint* (Taylor et al. 2012) was a self-contained device unit that could be mounted on a wall or flat surface, allowing people to vote both with a mobile phone as well as by pressing physical buttons. The interface showed two information windows: (a) a question box with voting instructions and (b) a small screen displaying current results and cumulative number of votes. A rotating dial allowed users to scroll through previous polls to see the final results and any response provided. Three devices were deployed for two months, each in a different location within the community: a busy convenience store; the foyer of a community centre; and in the window of a local housing organisation. The results from the studies highlighted aspects related to credibility, efficacy and format of the interfaces. In particular, they pointed to the importance of keeping the interaction design simple and the positive effects of deploying the interfaces into locations where members of the community would normally already gather to discuss community issues, taking advantage not only of architectural affordances, but also of the social interactions already in place.

Steinberger et al. (2014) developed *Vote With Your Feet* as a tangible plug-in interface exploring the social and spatial affordances offered by a bus shelter. That was augmented by allowing citizens to take advantage of their time waiting for public transport to express their opinions on topics such as current affairs, cultural identity and local matters. The interaction mechanism was very straightforward and intuitive: a digital screen, mounted at the roof of the bus shelter, would display "yes/no" questions, one at a time. Once a question was displayed, people could cast their votes by stepping on one of two tangible buttons on the ground: one labelled with "Yes", the other with "No". Following the same principle of creating "serendipitous encounters" with the digital interfaces, *Visualising Mill Road* (Koeman et al. 2015) deployed low-tech polling devices in shops and cafes along a commercial road spreading two neighbourhoods, divided by a railway track. Each device was built from black cardboard boxes, embedded with electronic hardware to process and store the votes entered. On top of each device, a printed question was stuck above three buttons providing a canonical set of possible answers: agree, neutral or disagree. Citizens could vote in front of participating shops, in a way that would catch their attention as they walked up and down the street. Cumulative results were visualised with marks stencilled with coloured chalk spray along the street in front of each shop, exploring the affordances of visibility and walkability offered by the sidewalk pavement.

Adopting findings from the studies described above, such as making a conscious effort to keep the design of the voting interfaces simple, we developed our own case study. It consisted of a series of short deployments ran at our university campus, focused on testing the impact of certain contextual constraints on the observed participation by the general public. In the next section, we explain *why* we decided to investigate such a proposition, *where* we tested it, *what* interfaces we actually deployed, and *how* each interface was made available for citizens in the public urban space. Furthermore, we present the results of our studies and consider the design implications suggested by their outcomes.

4 A Case Study on City Hacking for Community Engagement

4.1 Why: Motivation

Above, we defined plug-in architecture as a process of opening up city-making and empowering citizens to develop plug-in choreographies as a set of new and situated social dynamics. As first line of enquiry, therefore, we decided to focus on the design of plug-in interfaces as elements fitting into the architecture and enabling choreographies.

When designing the deployment of digital interfaces to public spaces, researchers are repeatedly faced with three common contextual constraints: (1) the *technology familiarity* of the interface; (2) the *level of integration* of the interface into the built

environment it was deployed to; and (3) the nature of *pedestrian activity* ordinarily unfolding in the urban precinct. Technology familiarity refers to the extent to which passers-by would quickly make sense of the interface and learn how to use it upon a brief encounter in the public space. Level of integration relates to how much the interface blends into the surrounding architecture: for example, card readers on train stations are usually *installed into* local public furniture such as gates or station entrances (Fig. 3), while beverage machines or ATMs are often *placed alongside* other architectural elements in the public space such as walls or escalators (Fig. 4). Finally, the likelihood of passers-by stopping by an interface in a public space is determined by extrinsic factors such as the primary function of the space (e.g. connecting destinations, or else being a destination in itself) and the presence of other elements of interest nearby, such as shops, buskers, public art, benches or stairs (Mendelson 2015).

In order to get a better understanding about the impact of each of those contextual constraints in the levels of participation by the general public, we devised a series of field studies aimed at testing each of them with plug-in interfaces. The sections below describe our design approach for the study of each of those constraints.

4.2 Where: The Locations

To gauge the impact caused by the nature of pedestrian activity, we adopted two different locations for running the studies. The first location (L1) was a pedestrian crossing (Fig. 5(1)–(4)) on a busy wide avenue running through our university campus. The crossing is controlled by traffic lights both for cars and pedestrians, and pedestrians can indicate their intention to cross the road by pressing button-driven devices installed in electricity poles on each side of the zebra crossing. As we observed, pedestrians tend to adhere to traffic rules at that particular crossing, as it is located at a busy major road: they walk towards the area of the sidewalk immediately behind the zebra crossing (and therefore besides the electricity pole where the button-driven light control device is installed at) and then assess the status of the lights. If the lights are red, pedestrians press the device button and stand at the same spot for a few minutes waiting for the lights to go green. This waiting period offers therefore a window of opportunity for casual interaction with a plug-in interface.

The second location (L2) was a fully pedestrianised thoroughfare (Fig. 5(5)–(8)). Importantly, it was located in the same university campus as L1, so that we could ensure participation in all scenarios would involve members of the same community. The thoroughfare consisted of a 3-m wide concrete pathway running on a straight line through a small park flanked by faculty buildings on one side and a wide grassed area on the other. Sitting benches of different types are present on both sides of the pathway, which connects one of the campus' entrances and sport fields to a library, food court and other faculty buildings. As a result, the thoroughfare receives a continuous flow of pedestrians in both directions all day long.

Fig. 3 Transport card readers at a rail station in Sydney, Australia

4.3 What: The Plug-In Interfaces

As indicated by Table 2, to address technology familiarity (Blackler and Hurtienne 2007), we implemented two very distinct interfaces. The first (I1) consisted of a Web-based survey running on a 9.7-in. iPad Air (Fig. 6, left). The Web application would present the passers-by with a series of polar (i.e. "yes/no" questions). Walking up to the interface, participants would encounter a single question displayed on the iPad screen, above buttons corresponding to "yes" and "no" answers. Once participants answered the question, an animation would play confirming that the vote had been cast, followed by a visualisation of the cumulative results for that question gathered up to that moment, so that the participants could learn how their opinion stood in

Fig. 4 ATMs at a food court in Sydney, Australia

Fig. 5 Setups for the field studies

relation to their fellow citizens. After 30 s, the interface would display the next question, thus starting a new cycle.

The second interface (I2) consisted in a portable ready-made device using audio to ask "yes/no"-type questions to passers-by, once they were detected to be in the vicinity (within 3 m) of the device by a proximity sensor. After hearing the question (recorded by an English-speaking female actor), participants could cast a vote by

Table 2 Design scenarios addressing the contextual constraints

Contextual constraint		Scenario	Description
Where	Location	Pedestrian Crossing	People normally stop near the interface while waiting for the traffic light to turn green
		Thoroughfare	There is normally a steady flow of people walking past the interface
What	Interface	iPad	High technology familiarity
		Audio	Low technology familiarity
How	Configuration	Pole	Blended into existing street furniture
		Stand	New street furniture

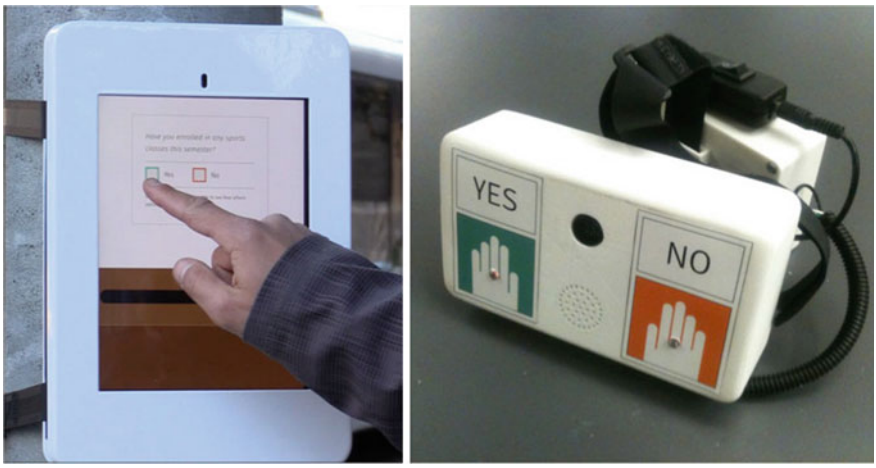


Fig. 6 Plug-in interfaces used in our studies

placing their hands on top of one of two cards labelled with "yes" or "no" (Fig. 6, right). The cards were embedded with sensors to detect the variation of light once a hand was placed on top of it, and a vote was only counted if only one of the two cards was covered. Like the iPad Web interface, upon computing a vote the audio device would present the participant with the cumulative results for that question, reading out loud how many other citizens had voted the same way. The cycle would then resume, with the device asking the next question if the participant stayed around or going silent otherwise until being approached by the next participant. The cycle would also resume in case of no vote being detected in the first place (e.g. if the participant walked away while the question was still being asked), timing out after waiting 10 s for a response.

Through those two interfaces, we sought to compare the effects of technology familiarity in the usage of urban plug-in interfaces for community engagement. We assumed the iPad interface to be perceived as more familiar—being a well-known device and given the fact we created the survey as a standard Web application.

However, we were interested in investigating how strong a role technology familiarity would play when presented in a rather unfamiliar context. Also, to facilitate the understanding of both interfaces, we designed them using a combination of very simple user actions, quick interaction cycles and complete independence between the questions, in order to produce *walk-up-and-use interface* scenarios (Jacucci et al. 2010). Our intention was to allow passers-by to join in or opt out from the interactions anonymously, at any time and at their own pace, therefore facilitating the interaction with the interface by individuals who would encounter them among other public space features in a way that was most likely sudden and unexpected. The same concerns with the passers-by choreography elicited by our plug-in interfaces led us to compose the survey with polar (i.e. "yes/no") questions rather than asking for more articulated feedback from participants: we designed the plug-in interfaces to take advantage of impromptu encounters with participants on their way to do something else as part of their daily routines—a requirement derived, in turn, from the architectural and social affordances of the chosen locations, as described above. Given that polar questions demand very little time commitment, we expected, by adopting them, to minimise the impact of time availability as a potential factor influencing participation. Had we designed interfaces to "plug into" a more accommodating public space—for instance, a public park with plenty of seating spaces, or even a bus stop, where people would dwell for longer—we could have afforded to design the survey for eliciting more articulated answers from citizens.

In order to isolate the survey content as a study variable, we asked the same questions on both interfaces. As we ran the study at a university campus during school holidays, we targeted the survey to the university staff community, asking five questions about sustainability and physical activity around the campus:

1. Do you drive your car to work?
2. Do you turn off your computer when you go on lunch break?
3. Do you use a reusable coffee cup when you get coffee or tea?
4. Are you able to control the air condition or heating in your office?
5. Do you take public transport to get to work?

4.4 How: The Interface Configurations

To test the level of integration of the plug-in interfaces into the built environment, we deployed each of them in two configurations. The first one was intended to give the interface a seamless character, well blended into pre-existing elements of the urban landscape. We chose to use Velcro straps to attach the interfaces to *poles* on each environment next to where people walked: on the pedestrian crossing, we attached them to the electrical pole also hosting the button-driven crossing lights device (Fig. 5(2), (4)); in the thoroughfare, to a tree at the edge of the pathway (Fig. 5(6), (8)).

While the first configuration would have the devices mounted on existing street furniture, the second should, on the contrary, cause the interfaces to stand out prominently on their own among the other elements in the local built environment. This second configuration, therefore, involved having the interfaces mounted on a portable stand, placed near the electrical pole (in the pedestrian crossing, Fig. 5(1), (3)) or the tree (in the thoroughfare, Fig. 5(5), (7)), but as clearly separate visual entities.

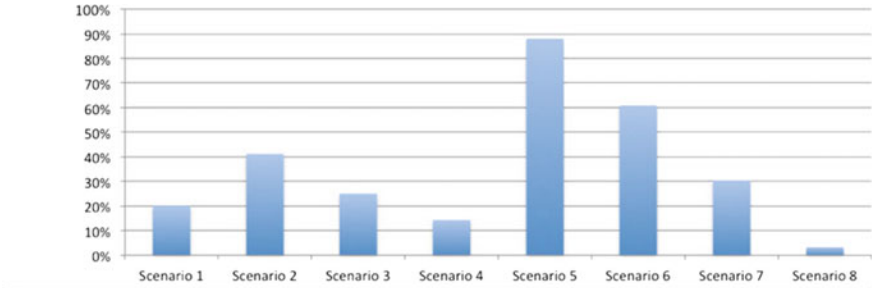
4.5 Methodology and Results

We ran a total of eight field studies, testing all combinations of the above variables. Each study ran for one hour, during which we recorded two metrics: (a) total number of passers-by who approached the plug-in interface under observation and (b) number of passers-by who actively interacted with the interface. For the purposes of this study, we defined *approaching the interface* as the act of walking towards it while aware of its presence, which therefore entailed slightly different behaviour depending on the location. In the thoroughfare, we counted passers-by walking within a range of up to 3 m from the interface and who performed active movements indicating their awareness of it, such as changing their walking pace around the interface, turning their heads to it or walking towards it. In the pedestrian crossing, we counted all people walking from the side of the road the interface was deployed to and crossing towards the other side, therefore incidentally coming within close proximity with the interface. Figure 7 shows the breakdown of the total number of participants per setup. The definition of *actively interacting* with the interface was the same for all scenarios: the act of making explicit gestures in or around the interface in an attempt to explore it further and cast a vote.

From the two metrics described above, we derived the *conversion rate* for each field study (also displayed in Fig. 7) as the percentage of passers-by who, having become aware of the plug-in interface, actually interacted with it. Combining the numbers per design scenario, across all studies, we then derived the conversion rates for each of them, as shown in Fig. 9. Likewise, Fig. 8 shows the distribution of participants when each design scenario is looked at in isolation.

5 Discussion

Before we analyse the results obtained from our studies, it is important to acknowledge their limitations. We should point out that the research questions presented in the previous section, although informed by all three theoretical angles outlined in Table 1, pose a much greater focus on aesthetic aspects that could influence public interaction (TA3). When designing our field studies, we aimed to prototype scenarios that could exemplify typical grassroots urban interventions. To that end, we designed our plug-in interfaces to re-contextualise community engagement sessions from



Number of participants	*15*	*17*	*4*	*7*	*25*	*23*	*23*	*31*
Crossing					√	√	√	√
Thoroughfare	√	√	√	√				
iPad	√	√			√	√		
Audio			√	√			√	√
Pole		√		√		√		√
Stand	√		√		√		√	

Fig. 7 Conversion rates per field study setup (tick marks indicate the features of each setup)

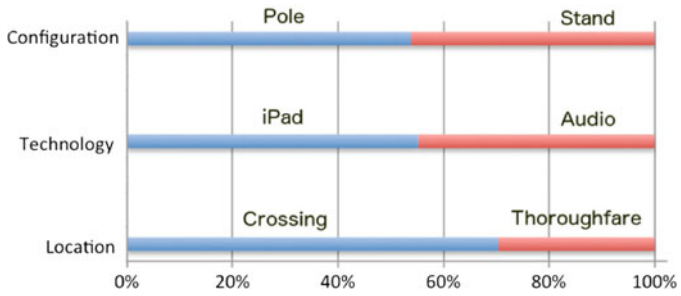


Fig. 8 Percentage of participants per design scenario

private to public spaces (TA1) and simultaneously avoid perceived accountability by government or administrative bodies (TA2). In addition to implying aesthetic decisions (as discussed below), such a departure point also assumed public spaces as test beds for our plug-in interfaces and a bottom-up approach to their deployment. That, in turn, got reflected in the "urban guerrilla" manner we designed our interventions, employing low-cost interfaces and running each session for a very limited amount of time: each study ran only for a short period (one hour) and, therefore, the total number of participants coming into contact with the interfaces was relatively low. Also, as Fig. 8 indicates, the percentage of total participants was somewhat unbalanced when location is considered in isolation, with more than two-thirds (70%) engaging in interaction with the interfaces at the pedestrian crossing. The distribution of participants across the other two contextual constraints—configuration and type of interface—was much more uniform: 54% pole versus 46% stand,

and 55% iPad versus 45% audio device, respectively. Given the reduced population sample, the studies can only offer preliminary impressions of the effectiveness of each design strategy regarding location, choice of interface or spatial configuration.

Despite those limitations, we believe the results obtained provide some important initial insights into motivational factors for impromptu interaction, intuitiveness of the interfaces and other relevant factors for consideration in the design of plug-in interfaces for community engagement, which we intend to explore further in upcoming studies. For example, from the metrics observed, the pedestrian crossing location seems to offer more favourable conditions for passers-by to learn and actively make use of the interfaces: not only the conversion rates across all setups (Fig. 7) were greater for the pedestrian crossing (43%) than for the thoroughfare (28%), but that was also the location for three out of the four setups with highest conversion rates (setups 5, 6 and 7, respectively), including the two at the very top (setups 5 and 6), as indicated in Fig. 7. This seems to validate the strategy of positioning the interface next to spots in the space where passers-by were already pre-conditioned to stop by (e.g. next to the button-driven crossing lights controlling device), therefore taking advantage of their natural behaviour in that space. We propose to refer to those spots within the public space where people would normally already stop by during their ordinary walk as *resting areas* and argue that they constitute a particular form of plug-in affordance. Waiting for the traffic light to turn green seems to offer people just enough time for noticing the plug-in interface, while the perspective to cross the street provides a suitable excuse for quickly trying it out before walking away. Since the normal routine of the pedestrian is not disrupted and requires little time commitment, participation becomes more likely.

Equally important, the context offered by resting areas is conducive to those kinds of quick interactions, unlike most other spots in a public space. As Aurigi (2013) pointed out:

> In many cases, terminals have been designed and placed to respond to a simplistic conception of touch-and-go usage by an idealised model of busy, 'always on the move' connected citizen. They depend entirely on an idea of fast movement space, and quick and casual interactions. […] They therefore end up being placed in entirely 'public' and over-exposed – and often rather uncomfortable – locations, forgetting that the nature of the interactions allowed by the terminal is rather personal and private. (Aurigi 2013)

The ubiquity of mobile technology and Web connectivity, however, have turned resting areas, even during ordinary circumstances, into spaces that offer people the opportunity to momentarily pause from other activities and engage in more personal, private and fleeting interactions with technology—in other words, into places for emergence of the augmented domesticity patterns of behaviour identified by Matsuda (2010). On those areas, and supported by digital technology, people would naturally start to feel able and comfortable to perform in public tasks previously reserved to the private home environment. For example, it is not uncommon to see people engaged with their mobile phones—e.g. making calls, checking their emails or quickly interacting with friends in social media—while waiting for the lights on a pedestrian crossing to turn green. The placement of plug-in interfaces for community engagement at or around resting areas encourages therefore situated participation by

leveraging directly on the local public space affordances, which are of both architectural and social nature.

This resulting *plug-in choreography*—which, importantly, also disappears from the public space once its corresponding plug-in interface is removed—has also found similar expressions in *Visualising Mill Road*, a study carried out by Koeman et al. (2015), who placed voting devices in a strategic location where people would already normally stop by: shop counters. While walking on the streets towards the shops, passers-by were gradually introduced to the community engagement campaign via the stencilled visualisations in front of the shops; upon entering a shop and stopping by the counter to pay for their goods, they would then have just enough time to engage with the voting interface without greater disruption to their normal routines, while all along feeling that they had contributed by participating in the civic event. *Vote With Your Feet* (Steinberger et al. 2014) also tapped into the local dynamics by having the foot-controlled voting interface deployed in a bus shelter—again, a location where people would otherwise have to stand idly anyway.

Even more significant, however, appears to be the effect of technology familiarity. As indicated in Fig. 7, all three setups with the highest conversion rates (setups 5, 6 and 2, respectively) employed the iPad interface. Across all setups, the iPad interface also resulted in a conversion rate more than 3.5 times higher than the one produced by the audio interface (57 and 15%, respectively, as indicated by Fig. 9). Those results strongly endorse the effectiveness of technology familiarity of the interfaces for participation. Despite the lack of explicit signage guiding the interaction, and the fact that neither interface constitutes a familiar feature in public spaces, passers-by still managed to swiftly make sense of the iPad-based setups and engage in interaction with that interface much more successfully than with the audio device. This is consistent with the literature on intuitive interaction, which argues that an interface will be perceived as intuitive if used in similar contexts as it is normally found at or, if used in a different context, it follows the same interactive rules as those on its original context (Blackler and Hurtienne 2007). A Web survey running on an iPad works the same way as it would be expected to run in any other context, hence passers-by making sense of it immediately. Our portable custom-made audio device, however, may not have presented sufficiently recognisable interaction mechanisms to allow for a swift uptake by passers-by in the community it was tested at.

Another important consideration relates to the utilisation of visual versus audio feedback for the interaction. Previous research (Hespanhol and Tomitsch 2015) has indicated that synchronous, immediate visual feedback—as the one provided by the iPad Web application, upon input from the user, is a relevant factor for conveying *identity*—i.e. for giving the individual interacting the sense that the interface is responding *directly to them*—and, therefore, forging a sense of *control*. Audio feedback, however, may easily become ambiguous: although our audio interface started playing upon identification of a person close-by, if the person walked away the device would continue to play; if a second individual then walked into the space, they would encounter the audio being played half way through, therefore losing the sense of being directly addressed by the interface. Likewise, if the surrounding

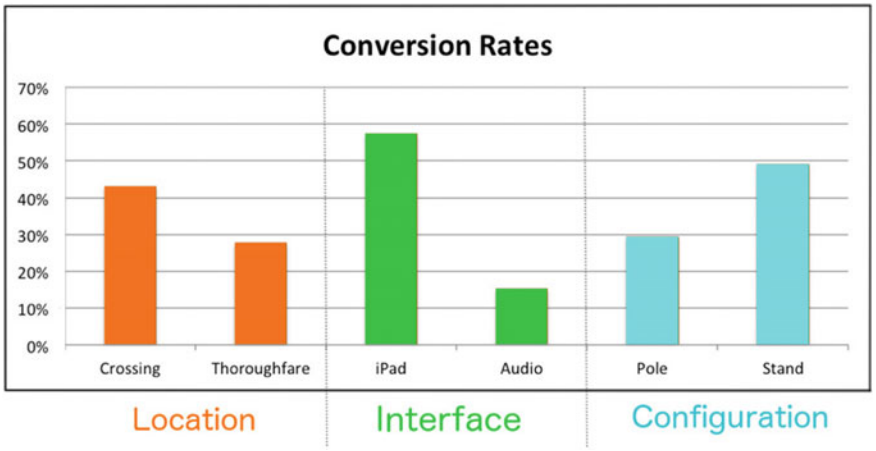


Fig. 9 Conversion rates per design scenario, across setups

environment became too noisy for the question to be heard, passers-by might not understand that the interface could be addressing them.

In regard to the mounting configurations, 3 out of 4 of the setups where the interfaces were mounted on a stand produced greater conversion rate than their counterparts where the interfaces were mounted on a pole (Fig. 7). Likewise, when looked at in isolation across the setups (Fig. 9), the stand configuration yielded a greater conversion rate than the pole configuration (49 and 29%, respectively). Such a result suggests that interfaces that are less integrated into the built environment are actually more effective in terms of attracting interactions from passers-by. Those results reflect some of the conclusions raised by similar grassroots city hacking deployments for community engagement. The design iterations reported in both *Visualising Mill Road* (Koeman et al. 2015) and *Vote With Your Feet* (Steinberger et al. 2014), for example, also pointed to the effectiveness of utilising elements that visually disrupted and stood out from the ordinary street aesthetics (chalk visualisations and extra signage, respectively). This strategy also corroborates the use of visual disruption in the urban space by other initiatives aimed at instigate civic engagement, such as the *London Is Changing* project (Ross 2015), which used billboards to display opinions about the city's affordability originally expressed online by members of the public. In all those scenarios, employing visual disruption in the urban space as a tool to attract the attention of passers-by to platforms aimed at civic discussions pose benefits that are twofold: in addition to the obvious increase in participation, it also presents citizens with views expressed by others, potentially in conflict with their own. In doing so, it counteracts one of the challenging factors to the public discussion of ideas in modern society: *filter bubbles* (Pariser 2011). A result of the automatic selection of news, topics and opinions by online search engines and social network based on a user profile, filter bubbles emerge by the algorithmic tracking of an individual's preferences, subsequently feeding an increasing presentation of materials related to

their own interests, thus reflecting their own world views in detriment of others in contrary. By employing visual disruption to persuade community members to pause in a public space where they can get acquainted with a wider range of views from their peers, plug-in interfaces can therefore strongly contribute to more balanced civic debates and increased agency and accountability (TA2) of the views shared by citizens (Hespanhol et al. 2015; Valkanova et al. 2014).

The considerations above, as well as observation from the literature, point to some clear strategies to be observed in the upcoming design of plug-in interfaces as lightweight tools for similar bottom-up initiatives:

Simple, clear and familiar interfaces, adaptable to the circumstances

As expected, walk-up-and-use interfaces that can be immediately understood, read and accessed lead to greater participation rates. However, care should be taken so that such clarity is kept despite of changes in the weather conditions, loudness or other distractions of the environment and demographics of the general public.

Quick interactions, placed in or around resting areas

As verified both in our pedestrian crossing scenario as well as in similar studies—like *Visualising Mill Road* (Koeman et al. 2015) and *Vote With Your Feet* (Steinberger et al. 2014)—the combination of quick interactions prompted in locations, where people would already stop by during their normal routines, creates a comfortable context that encourages engagement.

Low integration and distinctive aesthetics

Prominent features that cause interfaces to stand out from other urban elements result in greater participation, as verified by the greater conversion rates generally produced in our studies when the interfaces were mounted to a stand. The effectiveness of low integration and distinctive aesthetics has again also being verified in the recent related research by Koeman et al. (2015) and Steinberger et al. (2014).

Iterative prototyping via human-centred, participatory design

Participation levels can be increased by tailoring the interaction to the demographics and patterns of behaviour of the local community. Since those may vary overtime around the public spaces the interfaces are deployed to, multiple iterations of participatory design are required to uncover the patterns of behaviour and interaction of the local community members. By definition, plug-in interfaces must be lightweight enough to be deployed and pulled out multiple times.

Contextualisation of the interface

When designing our field studies, we were interested in comparing pairs of opposing design approaches (TA3) against specific contextual constraints, therefore testing the impact of each on participation. To address those objectives, we decided not to make use of any external signage explaining what the interfaces were for—a factor that potentially contributed to the low participation rates observed. As Koeman et al. (2015) pointed out, in addition to the attractive visual aesthetics of their voting

devices, factors found to significantly encourage community-wide engagement were the participating shopkeepers and the media. The involvement of shopkeepers, in particular, was relevant for providing unsolicited endorsement of the process by people perceived as peers within the community. Similarly, the *PosterVote* (Vlachokyriakos et al. 2014) sessions run by a community group were perceived as having higher degree of governance, therefore lending a more official atmosphere to the process.

As Taylor et al. (2012) pointed out, "if the results of a poll, the response posted or the device itself cannot be trusted or are not seen as legitimate, then this impacts the ability of the device to provide a sense of efficacy". Based on our results and on the findings from the literature, we argue that the observation of the points above during the design of plug-in interfaces can increase its credibility and, consequently, the trustworthiness of the community engagement campaign.

6 Conclusion

In this chapter, we presented the concept of plug-in interfaces: portable interactive technology deployed directly to public spaces on a temporary basis and addressing pre-existing architectural and social affordances. We derived the concept from the observed increasing popularity of bottom-up activism initiatives and practices of "hacking" the city for situated, purpose-driven design interventions. Plug-in interfaces allow citizens to appropriate and subvert sections of the city for controlled and temporary manifestations of urban activism, reversible by nature and limited in duration. By bringing rapid prototyping and continuous improvement into the urban planning field, plug-in interfaces turn community engagement into city hacking, by promoting iterations of direct and situated consultations with the general public as well as with stakeholders.

After an overview of related research in the field, we presented a case study on the utilisation of plug-in interfaces for community engagement. In particular, we sought to gain further understanding about approaches to address three core contextual constraints recurrently faced by studies of this nature: (1) *technology familiarity* of the interface; (2) *level of integration* of the interface into the built environment; and (3) nature of *pedestrian activity* ordinarily unfolding in the urban precinct. We presented the eight setups ran in the studies as well as the metrics observed, from which we derived conversion rates per setup as well as cumulative by design scenario. We then discussed limitations of the studies as well as an analysis of the results, reflecting on motivational factors for impromptu interaction with, and intuitiveness of, the interfaces.

Our analysis points towards design aspects that should be favoured in the design of plug-in interfaces as lightweight tools for similar bottom-up initiatives. Aspects worth of consideration include: (a) use of simple, clear and familiar interfaces, adaptable to the circumstances; (b) quick interactions, placed on locations people would normally stop by (resting areas); (c) low integration and distinctive aesthetics; and (d) iterative prototyping via human-centred, participatory design. Furthermore, a

greater contextualisation of the interfaces regarding their purpose in the public environment might have helped to make them more trustworthy among members of the community and, consequently, increased participation.

We adopted the notion of plug-in interfaces from speculative design in architecture (Merin 2013; Sadler 2005) as well as from software design. In both instances, plug-ins are used to extend existing systems by adding new features that can be easily adapted and removed without compromising the core functionality of the hosting system itself. In software design, the development of plug-in interfaces is supported and encouraged through the provision of application programming interfaces (APIs). In comparison, cities do not yet offer similar frameworks that allow anyone to develop and deploy plug-in interfaces. The studies discussed in this article, including our own, attempted therefore to leverage on existing architectural affordances to design plug-in interfaces to appropriate the built environment for the purposes of community engagement. In that sense, the current state of plug-in interfaces is more akin to hacking, compared to the more established, formalised and supported development of plug-ins for software applications—in our study, for example, we "hacked" the environment by attaching polling devices to existing urban elements or deploying them into existing spaces. However, as the digital layer of cities develops and the concept of smart cities matures, it may indeed be possible to conceptualise cities as operating systems (Tomitsch 2016) with a more formalised API consisting of input and output channels—such as the number of people or vehicles passing through a space, for instance—that any citizen could build on.

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