Chapter 28

The Digital Home: A New Locus of Social Science Research

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In this chapter, we explore the hypothesis that emerging technology, in the form of the digital home, could provide a new way of exploring the implications of a digital lifestyle for consumption, policy, and social research purposes. We will illustrate how these methods are implemented by describing a working prototype of future digital homes called the iSpace and a methodology that empowers laypeople to customize the functionality of their digital homes called PiP. The ability of lay-users to customize products provides a powerful tool for market and social researchers to gain an insight to the needs and behavior of ordinary people. Moreover, a central innovation made possible by the technologies in digital homes is the opportunity for researching how the disaggregation of control over resources and institutional decision making evident in other parts of the information economy and networked world work in a model that is scalable from household to neighborhood, state, and beyond. We also discuss how and when the data from a digital home might add value to existing social survey and marketing approaches.

28.1. Introduction

28.1.1. Digital Lifestyles and Homes: A Multidisciplinary Vision

The vision for a digital lifestyle refers to the extensive integration of computing and communication technologies into our everyday lives, to such an extent that people and technology form symbiotic relationships, supporting an ever richer, more engaging, and deeply connected set of experiences. The notion of lifestyle implies the idea of change; that our "digital lifestyles" (our behavior, expectations, etc.) change incrementally with technological innovations and acceptance. Also, the consumption of digital technologies, and to some extent, lifestyle, is about choice (either unconscious or conscious). Thus, the

vision for a digital lifestyle is highly multidisciplinary in nature embracing social and physical sciences in equal measure. Lifestyles are rooted in real-life environments such as homes, offices, transport, and cities where people live. It is possible to use real environments that ordinary people inhabit as test beds for new technology, a concept that has been dubbed a "Living Laboratory" by the EU who have established a network of facilities labeled the European Network of Living Laboratories (http://www.openlivinglabs.eu/). The iSpace used in this paper is an example of a Living Lab and is part of this European network.

An example of a digital lifestyle environment is the digital home in which most electronic appliances and systems feature a network connection. The arrival of Internet has enabled all manner of home appliances and devices to be connected to networks making it possible to adjust heating, open shutters, check that lights are off, start the washing machine, set the alarm, show who's at the door, and check that a baby is asleep, even when away from home. Moreover, by connecting information and media sources to networks, it becomes possible to create new forms of entertainment, work or play by, for example, delivering films on demand or teleconferencing among friends.

Delivering this vision is not easy, and is the subject of ongoing research with many technical issues being considered such as end-user programming, security, reliability, and maintenance (Callaghan et al., 2007). Thus, there are also many pitfalls that can lead to poor acceptability and, consequently, living digitally poses a number of challenges to designers and users on a variety of technological, social, political, and cultural levels that we will discuss as part of this chapter (Johnson, Callaghan, & Gardner, 2008).

In order to investigate the possibilities for such digital homes, a handful of test beds have been built around the world to explore future visions where there is the progressive "instrumentation" of social environments through, for example, mobile and ubiquitous computing devices. In this paper, we draw on work from one such digital home test bed: the iSpace based at the University of Essex. The iSpace is a two-bedroom apartment built from the ground up to allow experimentation with new network-based home appliances and systems.

In this chapter, we propose that such digital homes offer an opportunity to provide useful social research data in a number of ways. Most basically, we can gather behavioral data that is produced as a by-product of a digital home. However, as the technology

allows for innovative use of this data by households themselves, a rich seam of data on collective behavior and decision making for social research can be made available. For example, a family might govern the operation of their home appliance (manage) to conserve energy that would benefit them (lower energy bills) and the community (less greenhouse emissions). The smart technology (novel forms of sensors, agents, human-computer interaction (HCI), and networks within the home), under the management of the home occupant, collects usage data that is transmissible by Internet. From a single household level, and with the agreement of the occupants, the data can be transmitted to a variety of agencies (including for social research purposes), and Internet forums can be used to engage with other households to produce a collective for managing resources that is a blend of community and organization.

For social science, the greatest potential interest lies in the theoretical significance of this innovative use of technologies, but the greatest challenges are methodological as we will discuss later in the paper. The implications for social research go well beyond examining usage and behavior patterns of particular appliances. The digital home potentially offers one insight into a revolutionary way of organizing society as already argued by some in social science. In the 1960s and early 1970s, sociologists suggested that industrial society would give way to the "information society" with consequences in all fields of human endeavor (Bell, 1973). Later, Manuel Castells (1996) argued that the world is entering an "information age" in which digital information technology "provides the material basis" for the "pervasive expansion" of what he calls "the networking form of organization" in every realm of social structure (p. 468). He predicts new forms of identity and inequality, submerging power in decentered flows, and establishing new forms of social organization. More recently, Hardt and Negri in *Empire* (2000) have considered the consequences of the computer revolution and the widespread adoption and development of ubiquitous, pervasive, and ambient computing, which they argue will lead to a totally new postindustrial, informatization mode of production. For example, they argue that wealth creation will move from the manipulation of physical resources (e.g., mining coal from the ground) to information resources (e.g., mining knowledge from large collections of computer-based information servers). The effects of this, in terms of population behavior, were also considered by Clarke, who considered various scenarios and the consequences for the population as a whole (Clarke et al., 2007).

This chapter will first outline the emerging technologies that are refining existing research methods and enabling new forms of researching social behavior. Given the reach of these new technologies, there are clearly ethical issues relating to privacy, confidentiality, and access that should be addressed and that we will discuss below. We conclude by discussing the implications and limitations of the digital home for social and market research.

28.2. The Smart Home and the Digital Population Observatory Model (as a Concept)

There have been several research projects concerned with designing systems for realizing digital homes. By way of a few examples, Georgia Tech's "Aware Home" (Abowd & Mynatt, 2005) and Microsoft's EasyLiving project (Brumitt, Meyers, Krumm, Kern, & Shafer, 2000) that have investigated context aware systems (systems that present users with functions and options that change according to the users context). The Adaptive House project in Colorado (Mozer, 2005), The University of Texas Mav Home project, (Cook, Huber, Gopalratnam, & Youngblood, 2003), and the University of Essex iSpace (Hagras, Doctor, Lopez, & Callaghan, 2007; Doctor, Hagras, & Callaghan, 2005) have investigated a variety of artificial intelligence techniques to model user behavior and preemptively controlled the environment to meet the users' needs creating the so-called smart home.

A key feature of a smart home is that networked devices can be made to coordinate their actions to produce meta-services formed from communities of coordinating services, functions, and appliances. Thus, the home of the future will be a deceptively complex place containing tens or even hundreds of pervasive network-based services, some provided by physical appliances within the home, others by external service providers. Services could range from simple video entertainment streams to complex home care or energy conservation packages.

There are many visions for digital homes that speculate on how network services might change the nature of consumer products and peoples' lifestyles. The general expectation is that domestic services would be designed, packaged, and marketed by

commercial companies. However, networked technology opens up the possibility to develop alternative models. For example, from a customer's perspective, it may be possible for end users (homeowners) to compose the functionality of digital homes based on aggregating coordinating sets of networked services. Such descriptions of composite services and their behaviors would form "virtual appliances" that could move with people as they migrate across differing environments (e.g., via the network, or contained in mobile phones), instantiating these functions wherever possible. For example, a homeowner could create a "*DVD Ambience*" virtual appliance that sets the ambient light level to a comfortable level whenever someone watches a DVD (by controlling the window blinds and the room's artificial lighting) or a "*Home Guard*" virtual appliance that checks and secures the home locks at bedtime. Naturally, there is a basic set of common needs that people have such as telephones, TVs, heating, etc., and these would form default "virtual appliances" in all homes. However, other, more novel, virtual appliances (composite service descriptions) created by lay people could even be traded between people as "innovations."

Further, this notion addresses the need in some people to be creative. For example, many people like to choose their own home furniture and wall coverings, personalizing their environments. The technology described in this paper enables these concepts to be applied to people "decorating" their own electronic spaces. In addition, this paradigm increases the control people have over the technology in their life, a requirement that numerous social research projects have reported as being essential to the acceptance of technologies in the home (Kook, 2003; Mäyrä, 2006).

28.2.1. The iSpace

The iSpace is a test bed for future digital or smart homes based at the Essex University campus. It takes the form of a two-bedroom apartment (see Figure 28.1), containing the usual rooms for activities such as sleeping, working, eating, washing, and entertaining. It comprises numerous regular but networked appliances such as telephones, media players, plasma screens, washing machines, refrigerators, lights, heating systems, etc., together with newer technologies such as speech and vision interaction (for commanding or configuring the environment), which interact with the user and sensors (e.g., detecting status of locks, food stocks, etc.) and tags (for tracking objects).

FIGURES 28.1a, 28.1b, AND 28.1c – The iSpace

The iSpace (the home) is situated inside a larger community framework (the iCampus), which includes a wider instrumented environment (bars, shops) and wearables. The iSpace or home is an example of the wider concept that embraces other environments such as offices, shops, etc., showing that methods can be extrapolated to the wider networked environment domain.

In the next section, we provide a brief overview of iSpace technology that enables people to create micro services and government within the home, which we argue, can be extrapolated to inform macro government models and policies.

28.3. The Technical Methodology

A core tenet of the hypothesis we are arguing is that there are useful parallels between people forming policies to manage, for example, energy usage in their home, and policies being administered by local or central government. For this strategy to be effective, the technology needs to maximize home owners' choice and control.

A number of significant studies have investigated digital home requirements. For instance, the Samsung Corporation, in cooperation with the American Institutes for Research (AIR), conducted a study aimed at identifying smart-home requirements by interviewing and monitoring people in South Korea and the United States (Chung et al., 2003) One particularly important requirement discovered by the Samsung and AIR study was the need for people to be able to customize their home, a finding supported by many other studies (Mäyrä et al., 2006). There are many visions for digital homes that speculate on how users might be empowered to customize the electronic functionalities of their own home. An example of such a concept is that of MAps (meta-appliances and

applications). MAps are "soft objects" that provide a means to aggregate elemental network services together to create virtualized forms of regular (e.g., TVs, air-conditioning, etc.) and novel (user created) appliances (Chin, Callaghan, & Clarke, 2009).

In terms of social science, MAps are uniquely useful as they form documents that described a person's real preferences with respect to some application or topic. For example, for energy policies, they would describe how a person set their heating in the home, office, or transport for a variety of differing contexts such as lone use, family use, or business. Thus, they are a rich and accurate source of data, albeit at a somewhat low and detailed level. However, they are amenable to higher-level aggregation over hundreds or thousands of people, potentially providing more meaningful higher-level statistics.

A key consideration to the design of the technology is how MAps are created (Callaghan et al., 2005). Chin has researched this issue and makes a strong case for nontechnical end-user methods that she sees as a key requirement to empowering the principle stakeholder of the digital home to engage with the technology (Chin et al., 2009). She points at two solutions, one based on highly automated autonomous agents that monitor people's behavior, using this historical information to build models that aim to configure the technology to meet the person's future needs. She argues that such approaches have drawbacks such as a reluctance of many people to allow their personal home spaces (and them) to be monitored by network-connected technology in this way and, second, that trying to second guess needs based on past experience will inevitably have annoying failures (as not all future needs will be described by past actions) and it does not allow creative thoughts for novel MAps that might exist in people's mind to be efficiently extracted. For those reasons, she has argued for and produced a prototype system referred to as PiP (Pervasive interactive Programming) that users can use to create MAps by demonstrating, in explicit teaching sessions, the behavior they require (for full technical details and needs see Chin et al., 2009). Being able to gather data on people's needs, by directly monitoring what they create (as against what people say they may like based on more abstract judgments), has the potential to provide more reliable, detailed, and timely information (Rowley & Wilson, 1975). In particular, our approach builds on "gaming" and the "priority-evaluator approach" to social research, which uses analogues

of the real world (frequently in the form of games) in which people are given the freedom to configure resources as a means to obtain more reliable social research data (Rowley & Wilson, 1975). In the approach being advocated in this paper, we retain the idea of monitoring how people configure resources as a means to elicit peoples' choices and desires but dispense with the use of analogies in favor of using new generations of configurable technology, in particular digital homes and PiP, which directly involves the stakeholders being studied. Incidentally, Rowley's work is also relevant to this paper as he is also credited with the earliest use of bespoke portable microcomputer technology to augment social and market research, concepts that further motivate this research (Rowley, Barker, & Callaghan, 1986).

Concerning the data yielded by such end-user customization systems, because people are able to create and design the functionality of their own virtual appliances or environments, their decisions and design actions represent valuable information in terms of understanding peoples' needs. This is especially so because the networked nature of the system makes collection of this data relatively straightforward for both individuals and aggregations of large numbers of people. However, rather than the data being conventional questionnaire-style answers, it is more complex as it contains details of assemblies (MAps) of functions, together with their usage. Inferring what the MAps do and why the user created them require meta-data tagging by the user at the time of creation. Usage statistics (when certain functions are used and for how long) can be automatically collected by the system. MAps and end-user programming are just one approach, albeit an important approach, to governing digital homes.

In summary, with respect to social science research the two methodologies described above (end-user programming and autonomous agents) provide a source of data on peoples' behavior and preferences. The agent-based approach represents more passive data gathered from monitoring peoples' behavior with little active input from the person being monitored. In contrast, end-user programming (and its PiP implementation) involves active participation of the home occupant in making decisions and forming policies. As such, we argue that the data gained from end-user programming is more linked to conscious decisions and policy making and thus more useful for extrapolating higher-level policy information. Decision making and its relationship to our hypothesis is discussed further in the following section.

28.4. The Model of Governance and Its Implications for Social Research

Emerging technologies such as the digital home have the power to disrupt and transform existing social structures and social practices. The "digital home," through networking appliances inside the home to each other and beyond the household via the Internet, offers the opportunity to generate usage data and allow people to manage and share that data via the Internet in a way that will have a transformative impact on consumption and decision-making patterns. The most innovative aspect of digital homes is arguably their ability to empower households to manage their own usage data and to deliberate with other households over whether and how to share this data with outside stakeholders, such as energy companies or government agencies. This disaggregates, and has the power to allow innovative reconstitution of, existing decision-making practices and relationships between providers of resources and consumers, and governments and citizens. Existing resource management and e-deliberation solutions can provide a means through which users can form and federate groups that can then electronically manage, reflect, and debate the best use of ambient intelligence resources in servicing their own needs and that of the wider community. By rendering such activities explicit, but by also providing user friendly Web tools to browse and manipulate the related models, communities can be enabled to decide clearly how to collect, monitor, process, and distribute sensor data.

Managing a home is in many ways analogous to the process of government. There are finite resources with much competition for them. Opinions and information need to be gathered, deliberated on, rules decided on within households (effective formation of policies), and actions taken (cf. a micro-government) (Callaghan, Clarke, & Chin, 2008). The household can engage in deliberation on how best to manage the household resources and then go online, if they wish, to engage in deliberation at three levels to exchange information and views on how to manage their data, and how that data is used: within the household between individuals; with other households in a selected group, specifically the street/neighborhood, municipal level; and between citizens and interested parties and government. This approach enables householders/citizens to manage their own bounded domain—their own data—and if they wish to respond as a household or as a collective to specific policy and engage in deliberation on this policy with the government and other citizens. The government in turn could modify its policies in

response to the findings and views of the households. These "micro-government" choices provide an opportunity for households to negotiate with commercial companies or state providers of resources, making the relationship much less passive and hierarchical than it is now. Taking the example of management of energy, existing technology can provide the means to monitor the power consumption of key appliances such as heating/cooling, lighting, hot water, washing machines, or TVs. Monitoring the individual power appliances is the minimal level of granularity needed to gain knowledge of personal behavior. This data from a digital home can feed policy formation as the data recorded can be transmitted to relevant parties/actors, for example, local municipal authority or central government. One can imagine a scenario where households, through negotiation, not only reduce their energy bills through the appliance specific data they are collecting but also could collectively share data on energy use with energy providers in exchange for lower fuel/energy charges. This would have implications for energy policy, including strategies to reduce the consumption of energy.

The emerging technologies used in "digital homes" offer opportunities to interrogate classical and contemporary social theories about the nature of social order. Contrary to some arguments in the Marxist tradition (Braverman, 1974; Schiller, 1976), rather than the information age leading to the increased control of capital through surveillance and deskilling and the further disempowering of labor, our model is part of a potential scenario where traditional power holders (capital, state) have some of their power decentralized or redistributed (Negri, 1988)—in this case, drawn down to households. IF (our emphasis) the lay user/worker/citizen is part of the process from the moment of inception, including easily customizable sensors, and IF there is use of the Internet forums for coordinating with other households, there is a significant new role for households and collectivities of households in the economy and polity. Households will have the information or data that the companies or state will require for efficiencies and this will provide bargaining power to previously passive consumers. The low level of cost for overcoming the hitherto material barriers for production of information (affordable sensors, access to Internet) means we have a scenario where anyone who is computer literate at a basic level will be able to own and manage their own information. Our model is aware of and tries to address this issue of access by including the means for customizing the sensors that does not require any technical knowledge.

With the ownership of data shifting to the individual, particularly the household level, and the necessity of negotiation for companies and bureaucracies who wish to gain access to the level of detail gathered, the structure and practice of institutions is impacted. Institutions, from household to companies to government, have, since the industrial revolution, been predominantly characterized by hierarchical structure and top–down authority relationships. The information revolution and postmodern society have provided the tools and consequences to challenge this in the family (Stacey, 1996), organizations, (Powell, 1990) and government (Keck & Sikkink, 1998; Slaughter, 2004). The rise of the "network society" (Castells, 1996, 2000) has changed the rules so that information flows now determine structure, boundaries are much less important (or indeed even possible), and status is determined much more by expertise than formal position (Holohan, 2005). Knowledge has never been more democratically distributed or available regardless of formal status. Politically, this offers a potential citizen–polity relationship that goes well beyond the franchise, and allows for deliberation and input into policy decisions that is unprecedented (Habermas, 1991; Calhoun, 1993).

The "networked information economy" (Benkler, 2006) is challenging the old "industrial information economy." This is producing a society where decentralized individual action, specifically new cooperative action carried out through radically distributed, nonmarket mechanisms that do not depend on proprietary strategies, is becoming increasingly important in the fields of communication, information, and culture (Lessig, 1999). For instance, the music industry has moved from dominance by huge music companies to a much more diffuse and democratized model of music publishing and performing. The material barriers are largely gone (due to technologies, principally the Internet) and nonmarket, nonproprietary motivations, and organizational forms are increasingly common, resulting in effective, large-scale cooperative efforts such as the Open Source software movement. Eric von Hippel's idea (1988, 2005) of "user-driven innovation" has begun to expand that focus to thinking about how individual need and creativity can drive innovation at the individual level and its diffusion through networks of like-minded individuals. It is this feasibility of producing information through social (cooperative and coordinated individual action) rather than market or proprietary relations that is at the heart of our proposed model of scalable governance of households using data that is produced by sensors and shareable with others through the Internet. So

for instance, householders can choose to share information on energy consumption not on demand from companies or government nor in a market place but through collective deliberation and deployment of data for specific purposes, such as assisting energy efficiencies to address challenges from global warming. The collective deliberation could be at a street level or neighborhood level or municipality or city ward level. While there are threats to privacy (discussed below), there are also benefits. For example, by participating in energy usage monitoring programs, ordinary citizens can both help the environment and save money by using less energy. In addition, as such information might help make the energy providers more efficient, these savings could be shared with the consumer in the form of a discount providing additional incentives for the citizen to participate.

28.4.1. Privacy and Ethical Implications

The social sciences, and indeed society, need to grapple with the danger of technological developments proceeding at a pace that would realize the fears around privacy and "Big Brother" scenarios. The more attention social science gives to emerging technologies such as the "digital home," the more such dangers can be highlighted and addressed. Re-interrogating Marx and Weber, we can explore whether the new technology is increasing elite control of both politics and production through enhanced surveillance (Davis, Hirschl, & Stack, 1997).

Numerous reports have revealed that user acceptance of technology in digital homes has been shown to be linked to perceptions of privacy, which in turn is linked to the degree of control the user has over the technology (Chung et al., 2003; Mäyrä et al., 2006). In terms of digital homes, these issues have been linked to the balance of autonomous agents versus manual management of the environment (Callaghan et al., 2008). A search of the Internet will quickly reveal that much has been written over the years about such dangers. This fear is increased as our control, and system transparency, is reduced. Thus, if we are to live in digital homes, then questions such as "who has control?," "what is the extent of their control?," and "who has access to sensory data from our home and what use are they making of it?" are paramount. In terms of smart or digital homes, control comes down to the balance of technological autonomy versus user influence.

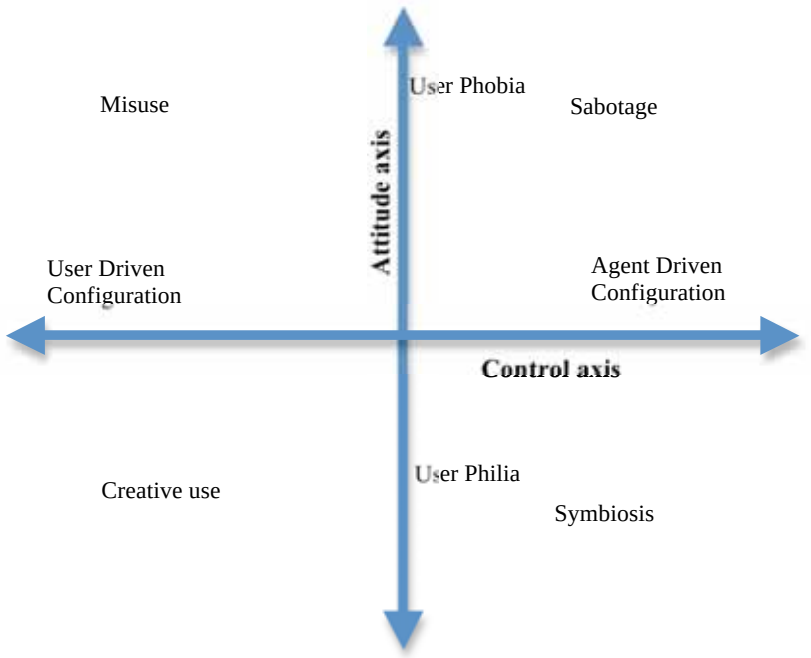

Figure 28.2: The 3C Framework for Digital Homes

These concerns are graphically illustrated in the two-dimensional graph shown in Figure 28.2: the "3C framework" (Callaghan et al., 2008). To capture the balance of automation, there is an autonomy-axis that depicts the possibilities for configuration from manual (end user) to automatic (agent based). In terms of sociology, reactions to technology vary from love to fear, which are illustrated in an "attitude" axis that shows user reaction (philia versus phobia) to the different possibilities. The quadrants show differing combinations of technology and attitude, identifying potentially significant positions within this space. A general assumption underpinning this model is the view that the less understanding of and control over their technological environment people have, the more resistant or fearful they will be of it (and vice versa). The model is not normative but depicts a conceptual space of possibilities drawn from experiences of our research. Thus, for example, people that are technophobic may react to automated environments (where they have little say in how they operate) by trying to sabotage the technology. For example, people may cover or disconnect sensors to fool the system or prevent it monitoring them. In a system where technophobic people have control over the system, they may simply program the system to disable it, or make it work in an unconventional way, as a means of expressing their dissatisfaction. This is in contrast to

the way people with technophilia tendencies may react. For example, for systems in which autonomous agents exercise total control over the environment they may marvel at the sophisticated technology and bask in the comfort it affords, whereas in a system that they can exercise control they may delight is creating novel functionalities. Of course these are extreme attitudes and behaviors and the diagram allows for more continuous variations.

Thus, in a digital or smart home the principal tool in the armory of privacy protections is control, which in practical terms resides in the balance of agent versus user management. By control or management, we mean maximizing the user's ability to make choices on what information is gathered and when and how it is used (including choices to "autonomise" the collected data). At a community level, this would require and enable groups at various levels of granularity (from families to neighborhood, town, and even to nations) to e-debate/deliberate what data should be made available to whom and for what purposes. Cheap storage, distributed systems querying, and perhaps peer-to-peer (P2P)-based backups could mean that sensor data could be stored relatively locally (minimizing exposure to massive theft and allowing the levels of security and robustness to be tailored to the group concerned).

In addition to people's desire for privacy, another barrier to people allowing detailed sensing of their domestic lives is rooted in a lack of trust in the officials or corporations who collect, store, have access to, and use such sensitive information. The 25 million personal data records lost in the United Kingdom in 2007 demonstrates the importance of addressing this issue. Local groups need to be able to negotiate about access of their data by "outside" bodies, for example, governments and corporation, from a position of power. These bodies would need to be forced to argue for access to data on the basis of earned trust, transparent procedures, and well-reasoned appeals to the common good or appropriate incentives. Agreement for access could be provisional (these are ongoing feeds of data so long-term relationships are key) and linked to systems for auditing security and usage and also for dealing with potential conflicts that may arise, for example, if one accessing body wishes to forward data to another one (a big concern with a lot of data privacy—you may trust the local police but not want them passing details to the CIA).

While in this paper we are focusing on the benefits of digital home technology, and how it might improve social research, which in turn could connect people and government in a more mutually effective relationship, it is equally clear that without careful planning and regulation of digital home technology it would be possible to create a modern equivalent of Bentham's Panopticon (Bozovic, 1995) or "Big Brother" (Orwell, 1949), turning homes into "gold-fish bowls" where our every move is monitored by third parties.

28.4.2. Blurring of Public and Private Spaces

As indicated above, it is already documented that the use of information technologies can itself pose a threat to confidentiality. The data collected and any accompanying communication that is typed rather than spoken leaves a physical trace referred to as a "data trace" that can be archived or preserved (Duffy, 2002, p. 85). Data traces can result in breaches of confidentiality if unauthorized people have access to research data stored on a computer that is connected to the Internet. In addition, in our example, protocols and standards for confidentiality need to be in place not just in the "smart home" but also in all relevant agencies: energy companies, government departments, market research companies, and social science departments in universities or research institutes. Such coordination represents a major challenge and can only really be addressed at the legislative level.

The difficulty in terms of the discussions via forums on the Internet, as to who and where and how to share the data, is the blurring of the boundary between public and private. Obviously, when people are in a public setting they can expect to be observed. Conversely, when they are in a private setting they do not. However, online this distinction is not clear (Barnes, 2004). Traditionally, there has been a clear divide between the public and private data with explicit consent required for inclusion of private data and measures taken to ensure that private data does not enter the public realm. But online flows of personal information are channeled through a public forum that poses no restrictions on audience access; anyone can view the discussion. Password-protected forums could be used, but this would restrict recruitment and participation in our proposed models; how else to entice neighbors over a relatively large geographical space, for instance to work together on sharing data, but to see the discussions and outcomes for

oneself on the Internet? Traditionally, it is the discretion of the subject that determines the boundary between public and private. But messages exchanged online often create an illusion of privacy because contributors forget that other individuals can read those messages. Once individuals develop close Internet relationships, they can easily forget they are communicating in a public space (Barnes, 2004).

One practical solution is to ensure that while the public can access the deliberation forums, participation in the discussion requires membership. However, this does not deal with the problem of confidentiality for social science researchers, as participants using pseudonyms merely make the ethical problem one of dealing with multiple identities, as unless similar pseudonyms are substituted, online identities are not hidden if actual pseudonyms are written up in the research, as participants can be recognized by those familiar with their online pseudonyms (Beddows, 2008). This situation presents an as yet unsolved dilemma for Institutional Review Boards (IRBs), which exist to ensure the subjects of social research and participants in social research's rights are protected.

28.5. Situating "Digital Home" Research in Current Social Research

It is useful in the discussion of the potential of "digital/smart-house technology" to distinguish on the one side between *technology-specific* and *general research* and on the other between *market research* in a broad sense (including audience measurement and market research feeding into research and development) and *social research.* By technology-specific research, we refer to research that is generally concerned with the adoption, use, and adaptation of "digital home technology" or with the consequences of "digital home technology" for attitudes and behavior of the users and the social structure they are embedded in. With respect to the technology-specific research, the issues may overlap between market and social researchers although market researchers will be more interested in the adoption and use aspects while social researchers will be more tempted to examine the consequences of the technology. We have already addressed this, focusing on the implications for social research, in our discussion of the proposed model of disaggregated decision making and scalable governance.

General research is research that is interested in topics that are independent of the "digital home technology" and in a target population that is not the universe of actual or potential users of "digital home." Here, the perspectives of market researchers and social researchers diverge more strongly: Market researchers will be interested in the use of products and the market chances for new products, while social researchers will be primarily interested in the social organization of the domestic sphere. In the following, we focus on the potential and limitations for general research.

Most simply, the data collected in "digital homes" improves continuous measurement. The idea of continuous assessment is not new—for example diary surveys and audience measurement have been around for quite a while. However, the initiative to call in or complete the diary usually rests with the respondent. Technology has already been identified by researchers as improving continuous assessment and is giving much greater access into people's lives. For example, transaction data is already in use (credit or debit card use, video rental, etc.) and continuous measurement has been linked to the growth of portable Internet devices and mobile computing—mobile phones, Blackberries, etc. (Couper, 2003, p.493). Traditional interviewer-administered surveys have very high costs for sampling, contacting, persuading, and interviewing, so interviewers have tended to maximize the interview and ask up to several hours of questions. Panel interviews, for the same high cost reasons, have tended to be months or years apart. However, there is existing evidence of the value of continuous measurement (Mundt, Bohn, King, & Hartley, 2002; Aaron, Mancl, Turner, Sawchuk, & Klein, 2004) and "digital home" technologies offer an opportunity to increase this value.

Collecting data in a "digital home" has potential for improving accuracy, as instead of surveying people's usage patterns in retrospect, where people report from memory, the hard data is much more accurate and complete. The pitfall of recall from memory is erased when you are working with real-time data; some obvious examples would come from research on diet, exercise, activities in the home, and mood. It also helps overcome observer fatigue: collecting data manually negatively influences the reliability of the data, apart from being very tedious, as the events of interest are rare and are interspersed with long periods of uninteresting activity (Philips Homelab http://www.research.philips.com/technologies/projects/homelab/index.html).

Thus, the core of the primary data to be expected from "digital homes" appears to be process-generated usage data from linked and integrated equipment. It is useful to compare the potential of usage data with the very established industry of audience measurement (e.g., Napoli, 2003). The data generated by "digital home technology" is similar to what is known as "passive" audience measurement data. Traditionally, meters were attached to working television sets to record set-tuning data for the household. The use of these data was limited and was complemented by diaries of the individual household members and by survey-based information about the sociodemography and other characteristics of the household and its members. Diaries have been largely replaced by "active people meters" that share with diaries the dependence on the active cooperation of the household members resulting in data of doubtful reliability. More recently, the emphasis is on "passive people meters" allowing also the recording of media consumption outside the home and reflecting the use of multiple platforms, in particular of the Internet. The infrastructure for audience measurement is a "single-purpose technology" set up because the data generated are of utmost economic importance, in particular in the planning of advertisement campaigns and the price-setting for television commercials. To secure that the audience data permit reliable and precise population estimates, audience measurement requires panels that are representative for the population of television viewers. This is typically done by some form of probability sampling. Panels need to be regularly updated to continue to represent the population and validated by "external coincidental surveys."

What are the implications of this tale for the potential of digital homes in social research? Of course "digital homes" may be useful for the "passive" generation of multiple platform media consumption data at the household level, and individual meters should not be a problem. But are there other areas for which "digital homes" can produce valuable data? Energy consumption may be another area and an intelligent energy monitoring system may help the end user to use energy more efficiently. But the energy producer has far less interest than television companies in details about who consumes their product—the revenue of the utility company is independent of whether a male in the age group between 25 and 34 consumes their product or a woman in her 70s. However, unlike audience measurement systems, "digital homes" are not set up because of the need to collect data. To the degree that data about usage patterns are the by-product of their

operation, setup costs are low and so are the marginal cost of generating (but not of processing) the data. Data generated by "digital home technology" may hence find interest from groups who would not be willing to invest massively in a data-generating infrastructure but see enough value in the data to cover the marginal costs and finance the processing of the data, for example, appliance manufacturers or home care providers. The integrated nature of the system, in addition, appears to permit one to examine interdependencies in the usage of different components in the house. This may guide the analysis of substitution and complementary effects between different components and identify more general patterns of consumption ("lifestyles"). Moreover, new developments such as PiP are intended to allow users to translate mental concepts into designs of lifestyles or home functionalities they would like, but currently do not exist, with important implications for product research and development.

Limitations in this line of research are, first, that the natural unit of observation is the household and individuals have to be identified to permit data with individual household members as the unit of observation. Second, the research is confined to "home consumption," while there are obvious and important interdependencies between "consumption at home" and "outside the home," as the trend in audience measurement toward "portable" meters recording mobile and public media consumption shows. Potentially, the core ideas of digital homes can be extrapolated to the wider networked environment domain easing this limitation. Third, for the foreseeable future, the weak point of "digital home"-generated data from the point of view of social research is the quality of the sample. High-quality samples are representative for the target population, and that is typically achieved by (1) a sampling frame that has high and unbiased coverage of the target population, (2) a sampling strategy that permits the generation of unbiased samples from this frame, for example, probability sampling, and (3) efforts to avoid low and biased cooperation and response rate.

Usually surveys are linked to individuals and thus there is the problem of how to differentiate individual from household in usage patterns. This has important implications for sample design and coverage. There is also not a stable sample of Internet users; unlike the real world, people, even if technically on an e-mail list, can choose to go "off-line." Participants can also mislead others about their physical location, identity, gender, or age, which means the researcher cannot effectively characterize his or her sample audience.

Participation in Internet surveys and online deliberation, if sharing data from digital homes, will be affected by people working from different technological platforms; in particular, access to appropriate equipment and Internet technology and variation in bandwidth all impact who participates.

At the time being, inhabitants of digital homes are a small fraction of the overall population in terms of socioeconomic characteristics and age distribution but also in terms of attitudes and traits not representative for the general population. Because innovators typically differ from late adopters of technologies, current people living in a digital home are also different from the universe of smart-house digital home inhabitants (including future ones) and the former cannot be considered as a representative sample of the latter. "Digital home" owners are hence a sampling frame with low and highly selective coverage of the general population. There appears to be no incentive for data users to equip a representative sample of houses with digital homes technology in order to avail of representative data—that is, a crucial difference to audience measurement. Additional problems may be posed in securing the cooperation and willingness to share the data by people living in digital homes, as was discussed above. This may crucially depend on how "intruding" respondents perceive the "smart-house" technology if used for research and how sensitive respondents regard the data transferred. Such noncooperation is unlikely to be random. With ubiquitous deployment not yet established, as of now "digital home technology" might be valuable in providing reliable data of highly selective samples for narrowly circumscribed fields in marketing research.

Less clear is how large the potential of usage data is for social research in the broader sense. First, scope of the recorded usage appears to be excessively narrow to command much social-scientific interest. For example, in a research field like the domestic division of work, even individually attributed usage data cover only a narrow range of household activities. Activities that are not technologically mediated or supported are not covered; domestic work outside of the house is disregarded; and for many in-home activities of technologically mediated or supported activities, recorded usage is at best proxy measurement of the household task being completed. Second, in the case that a variable of interest is generated by the "smart-house technology," there are severe limitations of "what you can do with the data" *if it stands alone*. The scope for experimental manipulation is limited and quasi-experimental designs of a "natural

experiments" type are the best one can hope for. Moreover, lacking random assignment as a mechanism to allocate people to treatment and control conditions, additional covariates have to be established to control for heterogeneity or allow matching of the groups. For observational studies, the problem of covariates is even more severe as (limited) causal inference requires measurement of the conditions expected to be the causal *agents* as well as antecedents and side-effect of this condition to eliminate spurious relationships.

All this would require that "rich" data are collected in addition to the process-generated data, using most likely "traditional" survey methods. For example, audience measurement data are not frequently used outside of their commercial applications and if so, then in highly aggregated form that permits one to link the data with other data sources (e.g., Hyland, Wakefield, Higbee, Szczypka, & Cummings, 2006; Frechette, Roth, & Ünver, 2007). Most studies on media consumption or media impact rely on self-collected data on media usage using either diaries (e.g., Couldry, Livingstone, & Markham, 2007) or self-reported usage (e.g., Chiricos et al., 1997), that is, data that are clearly less reliable than "passively" measured media consumption. A main reason is that social-scientific research is not particularly interested in purely descriptive studies of media consumption but either aims to untangle the processes generating different patterns of media consumption or to examine the effect of these patterns on behavior or attitudes. For both research interests, data generated by audience measurement are far too "thin" to permit meaningful social research and it is likely that the same holds for data generated by digital homes. Finally, most social research aims to be generalized to target populations and the quality standards are typically much higher in social research when compared with market research. Even if a highly salient dependent variable is recorded (or can be derived from data recorded by the "digital home technology") and relevant covariates are additionally measured, the fact that as of yet the inhabitants of "digital homes" are a highly selective group diminishes the value of the data for most social research.

The value added to qualitative research by "digital homes" is less obvious but nonetheless significant. As the researcher goes in with tremendous amounts of information already, it is much easier to orient the researcher theoretically and to focus follow-up questions and observation or just observation and in-depth interviews. Having

accurate usage patterns is useful, but interpretative data is also needed to fully understand the context of the use of sensors. In addition, the online forums—and potential accompanying off-line interaction—would be subject to ethnographic analysis. Online ethnography refers to a number of related online research methods that adapt ethnography to the study of the communities and cultures created through computer-mediated social interaction, in particular observation, participant-observation, and interviews. Some have contested that ethnographic fieldwork can be meaningfully applied to computer-mediated interactions (e.g., Clifford, 1997) but it is increasingly becoming accepted as possible (Garcia, Standlee, Bechkoff, & Cui, 2009). In fact, the term netnography has gained currency within the field of consumer research to refer to ethnographic research conducted on the Internet (Kozinets, 2002, 2006a, 2006b). The limitations of ethnographies of online cultures draw from its more narrow focus on online communities, its inability to offer the full and rich detail of lived human experience, the need for researcher interpretive skill, and difficulty generalizing beyond the community under study. These and the challenge of scale and confidentiality face the researcher of householders participating in forums to collectively manage household data.

Most promising from a social research point of view, as indicated in the discussion of a new form of scalable household governance, is the potential of the technology to enable and record household decisions and their outcomes, such as rules, in a variety of ways. Research interested in understanding how decisions in households are formed and how contextual factors (e.g., income differences between the partners) affect the process and the outcomes would be keen to have access to data that would test models of household decision making (or joint decision making of a group of households). Model-testing research is also less dependent on sample representation, if the goal is to test theories about general mechanisms and is more concerned about the internal validity of the findings rather than the external validity (similar to laboratory experiments).

28.6. Conclusion and Future Directions

This paper has explored the hypothesis that emerging technology, in the form of the digital home, can provide a new way of exploring the implications of a digital lifestyle for consumption, policy, and social research purposes. We illustrated how these methods

are implemented by describing a working prototype of future digital homes called the iSpace and a methodology that empowers laypeople to customize the functionality of their digital homes called PiP. The ability of lay-users to customize products provides a powerful tool for market and social researchers to gain an insight to the needs and behavior of ordinary people. We also discussed how and when the data from a digital home might add value to existing social survey and marketing approaches. For social science, the greatest potential interest lies in its theoretical significance but the greatest challenges are methodological.

Most significantly for social theory, emerging technologies such as the digital home have the power to disrupt and transform existing social structures and social practices. The "digital home," through networking appliances inside the home to each other and beyond the household via the Internet, offers the opportunity to generate usage data and allows people to manage and share that data via the Internet in a way that will have a transformative impact on consumption and decision-making patterns. The most innovative aspect of digital homes is arguably their ability to empower households to manage their own usage data and to deliberate with other households over whether and how to share this data with outside stakeholders, such as energy companies or government agencies. This disaggregates, and has the power to allow innovative reconstitution of, existing decision-making practices and relationships between providers of resources and consumers, and governments and citizens. In effect, this innovation can transform institutions and impact the existing power structure in society.

Methodologically, for current social and market research, the value of the digital home lies in its ability to enhance existing methods or elements of methods such as continuous measurement and the generation of passive user data. Limitations in this line of research include the difficulties with the unit of observation currently being the household rather than the individual; it does not investigate the important interdependencies between consumption "at home" and "outside the home" and finally, the quality of the sample is currently irredeemably weak. Although the use of such data for social research is thus circumscribed by the hitherto experimental nature of digital homes and their as of yet limited availability to the general population, there is clear movement in industry and academia to address these issues, with exciting possibilities opening up for both social and market research as a result. In particular, from the research

at iSpace discussed here, the possibility of accessing representative data of people's customization of appliances and the patterns of usage combination is one that would be of great interest to market researchers if sampling was not as problematic as it is currently.

Both, the theoretical and methodological potential and challenge of the digital home need to grapple with the danger of technological developments proceeding at a pace that would realize the fears around privacy and "Big Brother" scenarios. The more attention social science gives to emerging technologies such as the "digital home," the more such dangers can be highlighted and addressed.

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