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Julieta Matos-Castaño
University of Twente, The Netherlands

Anouk Geenen
University of Twente, The Netherlands

Mascha van der Voort
University of Twente, The Netherlands

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The role of participatory design activities in supporting sense-making in the smart city

Julieta MATOS-CASTAÑO^a, Anouk GEENEN^a, Mascha VAN DER VOORT^a

^a University of Twente, The Netherlands

* Corresponding author e-mail: j.matoscastano@utwente.nl

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Abstract: We examine the role of participatory design activities in supporting sense-making while anticipating technological effects in smart cities. The effects of technology are not univocal. Therefore, creating smart city visions that enclose multiple meanings requires providing environments where stakeholders make the often-implicit processes of meaning attribution to technology explicit. We develop and test three participatory design activities to anticipate value changes and controversies in smart cities, and analyze how these activities supported seven sense-making properties. Our results show that visibilizing, reframing, and imagining are key characteristics of participatory design activities in supporting sense-making. Visibilizing technological impacts 'makes things public,' revealing existing perspectives and fostering new ones. Reframing technological impacts enhances empathy for diverse interests instead of treating smart cities as technical problems. Imagining supports understanding connections between technology and society to anticipate impacts. Our insights contribute to the provision of participatory design activities to articulate multiple meanings around smart cities.

Keywords: sense-making; smart cities; participatory design; technological appropriation

1. Introduction

Smart cities rely on the notion that using technology to collect, analyze, and apply data of city processes improves urban life (Vanolo, 2016). Fueled by enthusiasm about the opportunities of technology, public and private organizations launch multi-million programs for smart city development, leading to a pervasive 'smart city fever'. Although these programs help to capitalize on the technological benefits around efficiency and sustainability (Angelidou, 2015), the extent to which these initiatives fulfill the wishes of citizens and other sectors of society is under debate (Van Zoonen, 2016). Often, smart city strategies assume technology is universally beneficial, providing a vision that represents an ideal with clear objectives and imaginaries (Vanolo, 2016). In practice, as with any other socio-technological development, the impact of technology is not univocal.

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On the contrary, technology changes the way we are in the world and act, and its effects are often uncertain and subject to multiple interpretations. While anticipating the impacts of technology in smart cities, people allocate meaning to form assumptions as predictions about future events. Assigning meaning is an ongoing process in which people make sense of reality around them and how it changes. ‘Sense-making’ is the process by which people attribute meaning to the world around them (Weick, 1995). In particular, attributing meaning to technology relates to the concept of ‘technological appropriation’. This is a ‘sense-making activity that involves the interaction of people, with their existing knowledge and beliefs; technologies, representing a phenomenon that requires the attribution of meaning and its integration into the existing frameworks of understanding; and the world, as an active context against which the human–technology encounter occurs’ (Kudina, 2019; p.87).

In smart cities, stakeholders collectively allocate meaning to technological impacts, anticipating a future that has not happened yet. Since the effects of technology are broad, ambiguous, and uncertain; partaking in activities that make the often-implicit processes of meaning attribution of technology explicit can support the development of inclusive smart city visions. Here, design can play a crucial role. Design contributes to making sense of complex problems, giving them meaning, and synthesizing them in a coherent product or service (Kolko, 2010a; 2010b). It helps to allocate meaning to otherwise fuzzy and incomprehensible events, being supportive of people’s exploratory needs when trying to make sense of the world. In this study, we focus on participatory design approaches because they bring together heterogeneous groups of stakeholders in activities that elicit issues of interest, and manifest the existence of different meanings relevant to the urban context (Tironi, 2018).

Based on this premise, this paper explores the role of participatory design activities in supporting sense-making in the appropriation of urban technology. We reflect on how they open spaces to discuss and confront a diversity of meanings of technology in the city, essential for the development of inclusive smart city visions. To this end, we elaborate on how three making and telling participatory design activities supported sense-making in different collaborative settings. To operationalize the concept of sense-making, we examine how the participatory design activities supported each of the seven sense-making properties previously introduced in literature (Weick, 1995). Our results show that making and telling activities support sense-making in three different ways, namely: making technological impacts public (‘visibilizing’), helping people to frame technology from multiple perspectives (reframing) and triggering participants’ imagination to anticipate technological effects (imagining).

This article is structured as follows. We first introduce the relevance of sense-making processes in smart cities. Second, we refer to the connection between design and sense-making, as previously debated in the existing literature. Then, we narrow down to participatory design and describe three making and telling activities we developed and used in participatory settings to support sense-making. Furthermore, we present our results and discuss our learnings in the context of technological appropriation in smart cities. We finish

reflecting on how this could translate into insights for the development of approaches to develop inclusive smart city visions.

2. Sense-making in smart cities

In organization studies, sense-making is a process in which individuals or groups interpret novel, uncertain and ambiguous events to give meaning to the world around them (Weick, 1995; Colville et al., 2012; Maitlis, 2005). The process starts when people experience situations they cannot immediately interpret using their current mental structures (Kiesler and Sproull, 1982). People perceive them as surprises, triggering the need for explanations in a process through which interpretations flourish (Weick, 1995). It is the process by which actors (individual or collective) build situations they attempt to comprehend, involving the creation of frameworks for understanding (Maitlis and Christianson, 2014). Through collaborative processes of sense-making, people create a collective understanding of the world and a foundation of collective action (Maitlis, 2005; Weick et al., 2005; Meyer, 2019).

In smart cities, different sectors of society (companies, government, citizens, knowledge institutions) allocate meaning to how urban life changes because of technology, and what these changes entail for our ways of being and acting. Technology influences societal values (Forlano & Mathew, 2014; Royakkers et al., 2018), the lives of citizens (Vanolo, 2016) and often leads to tensions resulting from value diversity or conflicting agendas (Kitchin, 2014; Van Zoonen, 2016; De Waal and Dignum, 2017; Valdez et al., 2018).

Smart technology, in essence, interrupts a usual flow of urban experience, leading to changes that are difficult to explain. Technology is, therefore, a cue in a sense-making process where actors attribute meaning to its influence in the city. Prior literature acknowledges that, while confronted with the possibility of adopting a specific technology, technological appropriation takes place (Kudina, 2019). Technological appropriation denotes the attribution of meaning people give to new technology and how, during that process, people develop an implicit and explicit relation to technology, and update their frames of reference (Kudina, 2019). Encountering an urban technology, people make sense of it and attribute meaning to it relying on their own past experiences, socio-cultural embedding, and information from various sources. However, these processes are often implicit, and the meaning attributed to technology is contested by various stakeholders.

In this context, design in general, and participatory design in particular, can provide the means to make explicit a diversity of meanings encompassing urban technology.

3. Design and sense-making

Previous literature has acknowledged the connection between sense-making and design. Krippendorff (1989) states that design revolves around making sense and helping stakeholders provide meaning to events around them. According to Kolko (2010a; 2010b), during design synthesis, designers make explicit the typically implicit processes of sense-

making and framing, as they distill meaning out of data through interpretation and modeling. Boer et al. (2013) discuss how design activities incite organizational sense-making by triggering dialectical processes to make assumptions explicit and invite stakeholders to empathize with a human-centered perspective. Sanders and Stappers (2014) describe how design fiction can enrich, enlarge, and activate people's capacity for making sense of the future before getting there. Other studies (Hummels & van Dijk, 2015; De Jaegher & Di Paolo, 2007) provide insights into the connection between design and participatory sense-making, elaborating on how people participate in the generation of meaning and, in that process, they enact the world around them.

This paper adds to the previous body of knowledge by reflecting on how participatory design activities support sense-making in the context of technological appropriation in smart cities. To this end, we build upon Eneberg (2012), who provides an account of how design competencies support the seven properties of sense-making introduced by Weick (1995), as illustrated in the summary provided in table 1. Working down sense-making in seven properties allows having a workable framework for our analysis.

Table 1 Summary of sense-making properties and design properties

Sense-making properties (Weick, 1995)	Design competencies supporting sense-making (Eneberg, 2012)
1. <i>Construction of shared identities:</i> Selecting an interpretation of an experience, people are simultaneously defining their identity (and vice-versa).	Design integrates multiple perspectives from different stakeholders to create a collective identity.
2. <i>Retrospective:</i> Identification of patterns based on previous experiences and retrospective identification of patterns.	Design supports the development of several hypotheses based on previous experiences as an argument in a dialogue with different contexts to test different futures. Design helps to move to a fictive future and to anticipate what has not happened yet.
3. <i>Enactive of sensible environments:</i> People create their environment while making sense of it.	Design helps to materialize a specific context, and the creation of this context influences people's own interpretations and perceptions. Design helps to join the abstract and concrete thought while forming ideas as interaction takes place using sketches and prototypes.
4. <i>Social:</i> Allocating meaning is an individual and collective process that happens through interaction.	The use of prototypes, stories or sketches helps to share explicit and tacit knowledge. Design facilitates providing several possible alternative explanations of a problem.
5. <i>Ongoing:</i> Sense-making happens over time and constantly, triggered by new experiences and events.	A design process helps to punctuate and create moments that crystalize meanings.

6. <i>Focused on and by extracted cues:</i> Cues are recognizable structures that are the seeds from which people make sense of events.	Design provides triggers to have a coherent understanding of the context.
7. <i>Driven by plausibility rather than accuracy:</i> To allocate meaning, people need a coherent story rather than an accurate one.	Design helps to allocate meaning by (co) creating a coherent story that focuses on plausible outcomes rather to accurate ones.

Smart city projects involve heterogeneous groups of stakeholders with diverse interests and frames of reference around technology. Here, participatory design offers approaches through which stakeholders (designers and non-designers) generate, share and understand ideas about the future (Forlano and Mathew, 2014) to build shared understanding and vision of a future smart city (van Waart et al., 2015), and elicit issues of interest (Tironi, 2018). In participatory design, designers have tools to (1) make, (2), tell and (3) enact (Brandt et al., 2012).

- Making activities support the collective exploration of future ways of living and being by creating prototypes, tools or products (Brandt et al., 2012; Sanders and Stappers, 2014). These activities turn abstract concepts into concrete and tangible objects, evoking discussions and allowing the involvement of multiple perspectives and frames.
- Telling activities are about providing verbal descriptions about future scenarios (Brandt et al., 2012). These can be scenarios about anticipated experiences, or fiction (Knutz et al., 2016) that enhance cross-disciplinary reflection and reframing of socio-economic conditions for design. Telling activities draw boundaries in the thought realm to make futures tractable (Candy, 2018).
- Enacting is about imagining or acting out possible futures by trying things out (by use of the body) in settings that resemble or where future activities are likely to take place (Brandt et al., 2012).

In this study, we develop and analyze making and telling activities, namely prototyping, scenario development, and storytelling. We chose our focus on these activities as we consider the nature of making and telling to be supportive of enacting approaches.

4. Method

To explore how participatory design approaches support sense-making for the anticipation of technological effects in smart cities, we organized five sessions with various groups of stakeholders ranging from practitioners, students, and the general public. To this end, we developed participatory activities with the objective of testing how people make sense and anticipate the impact of technology in the smart city. We focused on two effects: (1) potential tensions emerging from the implementation of technology and (2) value changes. Following Brandt et al.'s distinction between making, telling, and enacting activities, our design activities corresponded to making and telling. Table 2 summarizes the sessions, the activities, the goal of the sessions, and the data collected.

Table 2 Overview of sessions

Activity	# participants	Type	Goal and type of session	Data collected
1	1st session: 25 2nd session: 14	Prototyping (make)	Anticipate value changes in smart cities. Workshop with students	8 forms filled by participants describing the process of prototyping. Pictures taken during the process of building 8 prototypes. Observations by researchers including the explanations provided by participants about the process (one per group).
2	1st session ~40 2nd session ~20	Scenario development (tell)	Controversies originating from the implementation of technology. Workshop with practitioners	Session 1: 5 scenarios written by participants. Session 2: 4 scenarios written by participants. Observations by researches during the group discussions.
3	1st session: 120	Storytelling (tell)	Envision value changes emerging from technology implementation. Design exhibit	120 stories written by participants.

4.1 Activity 1. Making: Prototyping to visualize value changes in smart cities

To support sense-making for the anticipation of value changes in smart cities, we organized a workshop focusing on prototyping potential value changes resulting from the implementation of technology. Based on Forlano and Mathew (2014), participants had to prototype a neighborhood based on a value. Accordingly, participants received a value card, had to discuss what this value meant to them, and prototyped a neighborhood based on the value.

Expanding Forlano and Mathew's approach, we unexpectedly introduced a technology card. Immediately after, we requested to reflect on and prototype how the values would change because of the implementation of a technology, and how this value changes would alter the neighborhood.

Figure 1 Prototype based on 'inclusion'

4.2 Activity 2. Telling: Development of scenarios to surface smart city controversies

Prompted by the tensions originating from technological implementation in smart cities (Kitchin, 2014; Valdez et al., 2018; Van Zoonen, 2016), we developed a workshop approach¹ to make controversies in smart cities explicit. Therefore, we developed a method where participants could individually develop their dream and nightmare urban scenarios. First, we probed participants showing a neighborhood and images of the type of urban data that companies and governments collect, and where they collect it. Then, participants developed their dream scenarios about how they would use technology and data in an ideal smart city. Later, participants reflected on the associated risks and nightmares to their dream scenarios; and discussed them within their groups to identify tensions and controversies resulting from the use of technology.

Figure 2 Visualization provided to trigger the development of scenarios.

1 Approach co-created with the Design Innovation Group.

4.3 Activity 3. Telling: Storytelling to anticipate changes in human values

During a design exhibit in 2019, we invited visitors to write a story about a future smart city. At the event, participants drew four cards from each deck and wrote a story about how, given a societal trend, smart technology could lead to value changes in our society. Our goal was to elicit people's imagination on the role of technology in cities and explore how they anticipate value changes as a result of the implementation of urban technology. Thus, we adapted the game 'Thing of the Future' (Candy, 2018) to the smart city context.

In our adaptation of the game, we provided four types of cards to participants: (1) Arc cards (A) including societal trends, (2) technologies (T) implemented in smart cities, (3) places in the city (C), and (4) human values (V). The first type of cards, 'arc', included societal trends related to growth, collapse, transformation and discipline, like the cards included in the original game (Candy, 2018). Arc cards provided the context for the stories of participants. The second type, 'technology', included technologies potentially implemented in smart cities based on the categorization provided by Forlano and Mathew (2014): screens and surfaces (i.e. touch screens, signs), networked artifacts (i.e. surveillance cameras), or technologies of the body (i.e. mobile phones, wearables). The third type of cards, 'city', consisted of urban places such as schools, post offices, train stations, and so on. The fourth card, 'values', included principles that are highly regarded by humans, such as freedom, friendship, inclusion, etc. To develop the content of the cards, the authors brainstormed as many cards as possible to have a card deck that provided enough combinations to trigger people's imagination and stories.

Figure 3 Card game used at the design exhibit

4.4 Data analysis

To analyze how the different activities supported the seven properties of sense-making, we developed and used the checklist included in table 3 to search for instances in the data that showed how the activity supported the sense-making property, and provide evidence of it. The first author of the paper analyzed the data. The second author, who attended the

sessions and was actively involved in the data collection, validated this analysis.

Table 3 Checklist to analyze the activities

Sense-making properties	Checklist for activities based on framework of table 2
1. Identity construction	The activity helps to integrate multiple perspectives and reach a single outcome/deliverable that elicits participants' perspectives on technology in an urban context.
2. Retrospective	Participants create a fictive environment to anticipate and attribute meaning to the future based on different perspectives on technological impacts and making use of past experiences.
3. Enactive of sensible environments	The activity supports creating a context and, while creating it, participants develop new perspectives and become aware of others. The activity facilitates making intangible concepts/constructs tangible, helping to join the abstract and concrete.
4. Social	The activity facilitates social interaction and supports an exchange of tacit and explicit knowledge. The activity helps to express alternative explanations of a situation.
5. Ongoing	The process is continuous and occurs over time.
6. Focused on and by extracted cues	Participants extract cues from their environment by being involved in the activity, understanding the context and implications of technology.
7. Driven by plausibility rather than accuracy	The activity helps to develop a coherent story, plausible but not necessarily accurate to understand the current context and potential implications of urban technology.

5. Results

This section describes how the use of the three *making* and *telling* design activities previously introduced supported sense-making while anticipating the impact of technology. We do so by elaborating on how each activity supported each sense-making property and providing evidence from the data.

5.1 Identity construction

Prototyping and developing scenarios supported identity construction by integrating multiple perspectives on urban technology in a single outcome. In activity 1, while prototyping a tangible representation of a neighborhood, participants negotiated the meanings they attributed to values, and agreed upon a common outcome per group. Prototyping helped to create a shared identity around the values governing the prototype and the effects of technology on those values and urban life. For example, one group built a prototype based on 'solidarity.' To this group, 'solidarity' meant 'sharing' both in terms of 'sharing their problems with others' and exchanging products and intangibles like knowledge. While prototyping, this team agreed on how the meaning attributed to 'solidarity' would impact the city configuration. The final prototype included areas to exchange food, share knowledge,

with the end goal of avoiding waste and minimize consumerism. This way, they stood for the meaning of solidarity as sharing among citizens.

In activity 2, scenario generation prompted participants to take an individual and collective standpoint about desirable or undesirable effects of technology. Building a collective scenario made participants decide for which value they stood and their concerns. At the end of the exercise, in groups, participants stood for a specific use of technology while collectively agreeing on the negative impact a technology could have on other values. For example, participants developed a scenario where technology provided services 'immediately and efficiently to people in need'. While thinking of associated nightmare scenarios, this team reframed the dream, and debated how this scenario put pressure on other values. According to them, this scenario could make people lose autonomy because they would rely too much on the system to take care of them. Besides, it would raise questions about control of technology since there would be a top-down mandate to determine what being 'in need' means. This way, this group built an identity where helping others was important while respecting people's autonomy and having transparency on who and how technology is being controlled.

In the storytelling activity, participants wrote the stories individually hence we did not identify instances of the creation of a shared identity.

5.2 Retrospective

Sense-making is retrospective: it happens with hindsight once an event has occurred and, to allocate meaning, people use a repertoire based on previous experiences. All three activities helped participants to allocate meaning to a situation that had not arrived yet, assisting them to imagine the future and providing a lens to frame the technological impacts.

In activity 1, participants built their prototypes using a repertoire of prior experiences to make sense of technological impacts. To make these prior experiences tangible, participants provided physical representations of metaphors. For example, while discussing the influence of surveillance cameras on solidarity in the city, participants placed eyes as watchers of urban activities. These eyes represented participants' past experiences while being confronted with surveillance technology.

For scenario generation and storytelling, participants created fictive narratives to anticipate technological impacts. In both cases, these narratives included hypotheses based on existing retrospective interpretations of how technology, values and cities are (or could be) interconnected. For example, in activity 2, a group wrote a dream scenario of a city where citizens could get personalized services everywhere. Reflecting on their own experiences on social media, participants reflected on the impact this would have on polarization and the creation of social bubbles: by personalizing everything people would not be confronted with other realities, distancing them. This example illustrates how the activity helped participants to move to a fictive future and allocate meaning based on prior interpretations.

5.3 Enactive of sensible environments

The activities supported creating a specific context and, while creating it, participants developed new perceptions and became aware of others. Furthermore, all three activities made intangible constructs like values embedded in a city tangible.

Building a prototype in activity 1, participants created an environment (a neighborhood) to reflect on value changes resulting from a technological implementation. Developing this prototype and ‘thinking with the hands’, participants reshaped their interpretations. For example, one group created a prototype for the value ‘romance’ and reflected on how wearable technologies would change this value and the neighborhood. While building the prototype, this group interpreted that romance and the elderly are not usually connected, so they thought of approaches to facilitate romantic encounters for senior citizens. Building the prototype upgraded their own perception and, by upgrading this perception, the prototype changed. For instance, realizing that buildings are often too far away for elderly to visit each other, participants started creating rooftop meeting-points to organize activities for senior citizens.

In activity 2, building dream and nightmare scenarios provided lenses to frame and reframe technological impacts. By reframing impacts, participants created a scenario, and their perception about a technological impact evolved during the activity. This means that, while creating a context, participants also created a new perspective. For example, a group developed a scenario in which technology could maximize efficiency by seamlessly synchronizing all urban activities. Imagining how efficient their lives would become, this team reflected on how such an efficient city would not leave any room for boredom or creativity, upgrading their own interpretation about the impact a technology might have on different values.

This was similar in activity 3, where participants used the cards to both build a future smart city narrative while making sense of the influence of technology on social values. For example, a participant wrote a story based on the following cards: (A) grow, (T) wearables, (C) graveyard, and (V) humor.

“Graveyards are (...) sad places. Visiting deceased loved ones, you run into other visitors. (...). Talking to others going through the same is a great way to deal with your feelings. Wearables that prompt humor-full stories about the deceased person help tackle the sad and negative feelings.”

While writing the narrative, the participant reframed her perception of graveyards from being a sad place to becoming humor-full due to the introduction of wearables.

5.4 Social

Prototyping and developing scenarios were highly social and, as described for ‘identity construction’ and ‘enactive of sensible environments’, the *making* and *telling* activities helped to externalize tacit and abstract value interpretations. Working towards a single prototype or scenario was a highly social process where participants listened to each other

and built awareness of the consequences of framing technology from different perspectives.

The storytelling activity did not happen in a group setting since participants wrote narratives individually. Although written individually, participants could share their stories with others in two ways: by hanging them in a wall during the design exhibit and by publishing them in a booklet that included all the contributions. The prospect of hanging or publishing their narratives encouraged participants to be part of a social process and share their stories, solutions or future projections with others, to express their perspectives on the impact of technology in the city.

5.5 Ongoing

Sense-making happens over time. The activities here presented took place in specific sessions. Subsequently, we could not observe a continuous and longitudinal process of meaning allocation.

5.6 Focused on and by extracted cues

All three activities provided cues to participants to notice technological impacts in the city so they could expand them into explanations of what was happening.

While prototyping, the introduction of an unexpected card was a cue to allocate meaning to unexpected urban changes. For example, following the previous example of 'solidarity', participants created a neighborhood based on 'sharing'. Getting the technology card ('surveillance cameras') was the cue to realize that 'solidarity' and the city configuration could change. After getting the card, participants made tangible modifications to the prototype anticipating a positive influence of surveillance cameras on solidarity by realizing the opportunities of real-time data.

The scenario generation activity provided a context (images of neighborhoods) and frames to imagine urban scenarios. After developing dream scenarios, the activity made participants reframe their dreams into nightmares. The introduction of this new frame acted as a cue to allocate meaning to the future by anticipating other technological effects that were not explicitly debated at first. For example, a group created a dream scenario where technology would make it easy for children to play in a residential area. However, providing a new frame to anticipate associated negative effects triggered participants to realize that it would be necessary to provide additional mobility solutions if the streets became playgrounds.

For the storytelling exercise, to realize that there was an urban change caused by technology, the main cue was the use of seemingly disconnected cards. Providing aleatory card combinations, participants reflected on not so obvious technological impacts. Consequently, the cards acted as cues of alternative relationships that might not have been initially foreseen by participants.

5.7 Driven by plausibility rather than accuracy

While making sense of events, people allocate meanings that are plausible rather than accurate. All three activities facilitated assigning meaning to representations of technological impacts that seemed reasonable but not necessarily an objective truth to be accepted.

In activity 1, rather than focusing on accuracy, the prototypes acted as plausible metaphors for urban changes resulting from technology implementation. For example, assigning a positive meaning to surveillance cameras connected to solidarity was not necessarily an exact prediction of events, but helped to manifest a shared meaning among participants.

In activity 2, using a dream/nightmare lens stimulated focusing on the plausibility of scenarios rather than their accuracy. The discussions were not about whether the scenarios could potentially occur or not, but aimed at building empathy among different participants' perspectives, and at having constructive debates about tensions originating from technology.

For the storytelling activity, the main goal was not to deliver predictive narratives about the future, but to reflect on the impact that technology might have on our values and allocate meanings to those potential future experiences. The activity supported this goal by using cards to stimulate people's imagination. For example, a participant wrote a story anticipating the influence of artificial intelligence on citizen interaction, where people could only communicate with each other by using chatbots. To this participant, technology would reduce language barriers, making it possible to live in diverse and multi-cultural cities. This example shows how the activity stimulated participants' imagination by providing combinations of cards to build plausible stories about urban futures that might not be accurate predictions but help to make sense of a future that could potentially occur.

6. Discussion

The previous section has provided insights into how the three activities supported sense-making in participatory settings. Based on our results, this section discusses the characteristics of the activities that supported sense-making in the context of technological appropriation in smart cities. We present and reflect on insights for the provision of participatory design activities to support the development of smart city visions that articulate and incorporate multiple meanings around technological impacts.

In our study, *making* and *telling* design activities supported attributing meaning to the effects of technology in three different ways, namely: (1) 'visibilizing', (2) reframing and (3) imagining.

First, 'visibilizing' is about bringing to the surface what was previously hidden. This was an important characteristic of the participatory design activities presented in this paper that supported sense-making. Prototyping, creating a scenario, or writing a narrative provided representations to make intangible technological effects tangible. These representations helped participants to understand what others stood for, and to build a shared identity by integrating various perspectives in a single outcome. Furthermore, by 'visibilizing',

the activities helped to structure social interactions, allowed participants to allocate plausible meanings and communicate them to others, and acted as cues to expand existing explanations of what was happening. Our results give insights into how participatory design activities support ‘visibilizing’, crucial for participation in this context, and to debate the anticipated impacts of technology. This is in line with Schoffelen et al. (2015) who, like Latour (2005), emphasize the importance of making things visible to encourage public debates concerning a wide range of issues. ‘Visibilizing’ the impact of technology is about ‘making things public,’ revealing and stimulating multiple perspectives to be expressed. In smart cities, participatory design can disclose differences among participants and articulate matters of concern. Since technological impacts in cities can be abstract and difficult to grasp, smart city visions can benefit from participatory design approaches that acknowledge controversies originating from the use of urban technology and move beyond the logic of solutionism pervasive in smart city discourses. In line with Tironi (2018), we consider it essential to rethink forms of collaboration that create areas of friction and counter-participation.

Second, building a prototype, creating scenarios, or writing a story helped to frame technological impacts from multiple perspectives, encouraging a reframing attitude towards the anticipated effects of technology that supported sense-making. This enabled participants to shift viewpoints by asking ‘what if’ questions and producing responses to alternative imagined possibilities. Upgrading their frames, participants negotiated new meanings in a social process, contributing to the development of shared identities. Furthermore, the activities enabled creating a specific context and, while creating it, participants developed new perceptions and became aware of others, being enactive of sensible environments. Last, while engaging in the making and telling activities, reframing acted as a cue to allocate meanings to the future by anticipating other technological effects that were not explicitly debated at first. Our results illustrate that the reframing attitude stimulated by the participatory design activities enables an increased appreciation of, and empathy for, the interests of multiple sectors of society, instead of deploying solution-oriented approaches that only treat smart cities as technical problems. As stated by Van Waart et al. (2016), developing this empathy is essential to stimulate mutual understanding and a shared vision of a desired smart city. Since the effects of technology are ambivalent, approaches that allow for the manifestation of multiple meanings help to develop inclusive smart city visions that articulate differences instead of reducing them. With this view, similar to Björgvinsson et al. (2012), participatory design can provide platforms to provide ‘agonistic’ approaches, not to solve conflict but to constructively deal with differences.

Third, our results show how the activities triggered participants’ imagination supporting sense-making and its effort to understand the connections between technology and society, to anticipate its impact and act effectively. While engaging in making and telling activities, participants could reflect on the present with an eye that was not at hand, retrospectively thinking about their own experiences while containing cues for future-making. By fostering imagination, the activities helped participants to anticipate a future that was not there yet, providing cues to participants to notice technological impacts in the city, so they could

turn them into explanations of what was going on. Furthermore, the activities supported imagination to build plausible explanations rather than accurate ones required for sense-making. Our results illustrate how *making* and *telling* activities offer the means to trigger people's imagination to anticipate technological impacts. In line with Kukka et al. (2019), we consider it important to harness people's imagination to transform our ideas about urban life and project them into alternative futures. Imagining various technological effects supports surfacing multiple meanings, and stimulates critical debates about urban technology and its impact in the city. This critical attitude is important to avoid reductionist technocratic and top-down visions of the smart city that restrict stakeholders' imagination and limit the creation of solutions to the existing and future urban challenges (Vanolo, 2014). Participatory design can provide the means to trigger people's imagination, encompassing alternative meanings or interpretations of technological impacts.

7. Conclusion

Our study explores the role of participatory design activities supporting sense-making in the appropriation of urban technology, being relevant for design researchers and practitioners to reflect on how participatory design can open spaces to discuss and confront a diversity of meanings around technology and the city. Furthermore, our results provide insights for researchers and practitioners working in smart cities that use of participatory design to bring together heterogeneous groups of stakeholders for the development of smart city visions. Combining the insights gained from our understanding of the role of *making* and *telling* activities, our goal is to keep exploring approaches that acknowledge the differences in the meaning attribution for technological appropriation in smart cities. Furthermore, we aim at creating means that contribute to the design of cities that recognize the agency of urban technology and its relationship with its socio-technical context, in line with Forlano (2016).

In future research steps, we plan to explore the role of enacting activities. Following Candy and Dunagan's (2017) experiential scenario approach, our goal is to bridge the gap between abstract notions of technological impacts and embedded and embodied experiences on the ground.

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About the authors:

Julieta Matos Castaño is a postdoctoral researcher within the Human Centred Design group at University of Twente. Her research interests lie in the development of approaches to support collaborative futures making. In her current project, Julieta explores ways to develop inclusive smart city visions.

Anouk Geenen is a PhD candidate within the Human Centred Design group at the University of Twente. Anouk is interested in combining the hands-on approach of design with the theoretical frameworks from philosophy and science and technology studies.

Mascha van der Voort is full professor in Human Centred Design and scientific co-director of the DesignLab of the University of Twente. Her research aims at developing design approaches and tools that empower all types of stakeholders to actively engage and participate in collaboratively exploring and defining potential futures.