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New ways of thinking about the future Design fiction for public reflection to new and emerging technologies

While public appreciation is vital to technological inventions, the ramifications of these inventions remain extremely difficult to predict. This paper presents an original design fiction methodology intended to encourage public reflection on potential ramifications and desirable outcomes of technological advances. The paper first examines the theoretical considerations underpinning the methodology, including those from innovation theory, science and technology studies and design research. Next, it presents the approach using a case study of the public display of design fiction. The paper concludes with promising areas for future study.

Introduction

Because future developments remain extremely difficult to predict, discussions about the ramifications of new and emerging areas of science and technology necessarily operate within the realm of the unknown. While producing uncertainty, this unknown also encourages reflection on shared values, ethics and desirable futures. In order to develop sustainable solutions that can fulfil public needs, a broad variety of social actors must be included in these discussions. Such inclusion, however, poses a major challenge because of two main reasons: firstly, because technology assessment is always subject to uncertainty, ambivalence, and complexity (Renn, 2011); and secondly, because early public engagement poses methodological challenges (e.g., Collingridge, 1980; van der Helm, 2007; Heidingsfelder et al., 2015). The current speed of technological advancement and the transformative potential of new and emerging technologies – such as nanotechnology, artificial intelligence, synthetic biology, or bio-economics – reveal the relevance of public input and the necessity for the development of new methods of public engagement. In response, international research funding agencies have increasingly prioritised projects that promote social responsibility and encourage participation of the public and other important stakeholders in research and development (National Science Foundation, 2008; European Commission, 2011, 2013).

This paper examines how methods of design fiction can encourage public reflection on desirable technological advances, as illustrated by a publicly funded (design) research project named Shaping Future (2014-2017). The term design fiction was created 2005 by Science Fiction author Bruce Sterling. Since then , it has been adopted and shaped by designers and design researchers of different disciplines (e.g. Bleecker, 2009, 2010; Sterling, 2009; Grand and Wiedmer, 2010; Blythe, 2014). Design fiction prototypes don't show how things and socio-technical systems will be in the future, but open a space for discussion and public reflection: They "help one imagine and tell stories about new near future objects and their social practices" (Bleecker, 2010: 61). The project Shaping Future is funded by the German Ministry for Education and Research and aims at developing new methods for public engagement in research planning. Within this project, our team developed design-based methods to

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promote the multidirectional exchange between science and society, including participatory workshops and a public exhibition of design fiction prototypes. The main purpose was to enable laypersons to articulate their needs and expectations with regard to technological advances; and to utilise their input in research-planning and agenda-setting processes. The project was designed and evaluated by designers and social scientists based on current research and policy approaches such as Responsible Research and Innovation (von Schomberg, 2013; European Commission, 2012), Social Shaping of Technology (Jørgensen et al., 2009), and Public Engagement in Science (McCallie et al., 2009; Siune et al., 2009).

The paper begins with the theoretical considerations underpinning the project, then presents the approach, particularly in terms of the design fiction exhibition, and concludes with implications for further research.

Theoretical background

In the following sections, we describe the theoretical considerations that support the use of design fiction for encouraging public reflection on new and emerging sciences and technologies, focusing on socio-technical systems, new methods of knowledge production, and the use of participatory methods to engage multiple actors in research planning.

Socio-technical systems and new technologies

Following approaches from Science and Technology Studies (e.g., Pinch and Bijker, 1984; Jasanoff, 2004; Bijker et al., 2012), pTA (e.g., Durant, 1999; Joss and Bellucci, 2002) and cTA (e.g., Schot and Rip, 1997; Rip and te Kulve, 2008) we assume that technology and society are intertwined, mutually dependent, co-evolutive and co-constructive. They form socio-technical systems (Ropohl, 1979), a texture of material and social techniques (Grunwald, 2012). Involving societal actors in the development and the design of new technologies is thus fundamental to take societal needs, values and acceptance thresholds into account. Thereby, research and development can not only meet current political requirements of democratising innovation, but also include societal actors as key drivers of demand-oriented and marketable technological innovations (Edler and Georghiou, 2007). Yet, in the area of new and emerging sciences and technologies, technology assessment necessarily operates within the realm of the unknown and, according to Renn (2011), is subject to ambivalence, complexity and uncertainty. Ambivalence refers to the fact that technology always produces both positive and negative effects and therefore has no inherent moral status (ibid. 66). Its assessment requires weighing a variety of possible ramifications including environmental, social, and ethical. The criteria for such evaluation should ideally be developed in collaboration between policymakers and the public (ibid. 66-67).

Complexity refers to the numerous causal relationships between various factors that affect technological advances. These factors strongly depend on the contexts in which such advances take place, particularly socio-cultural. They include various synergies, both positive and negative, that may be extremely difficult to anticipate or considerably delayed in time. Because of this complexity, the predictions regarding the ramifications of technological inventions are necessarily inaccurate and the determination of research agendas extremely difficult.

These predictions continue to be subject to error and indeterminacies because the assessment of technology, as well as of the future in general, operates under high levels of uncertainty. Doorn and van de Poel (2012:1) identify yet another challenge of technology assessment: those who can be held accountable for particular developments often remain extremely difficult to determine and thus ethical standards are often extremely difficult to implement: *"The ethical literature thus often assumes: (1) that it [... is] individuals who act, (2) that the consequences of their actions are [... directly causally] traceable, and (3) that these consequences are certain. None of these assumptions seem to apply to many of the ethical issues raised by modern technology and engineering."*

Because prospective technological inventions may also be radical and/or harmful, key decisions should ideally be made at the outset of research and development and include not only technology specialists, but also societal actors. Moreover, such decisions should ideally include the establishment of legal and ethical norms, particularly in an

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absence of an elaborate *"morale provisoire"*, an accepted normative framework (Grunwald, 2000).

New methods of knowledge production
As modern information economies and their systems of innovation continue to evolve, the scientific community increasingly devotes its attention to new and emerging types of knowledge, contexts in which it is produced, and methods of its production, especially those involving public participation (e.g., Funtowicz and Ravetz, 1993; Gibbons et al., 1994; Etzkowitz and Leydesdorff, 2000; Nowotny et al., 2001).

Approaches such as Postnormal Science (Funtowicz and Ravetz, 1993), Mode 2 (Gibbons et al., 1994), and Mode 3 (Carayannis and Campbell, 2012) build on the assumption that scientific knowledge is necessarily incomplete (Gibbons et al., 1994; Nowotny et al., 2001). While the more conventional Mode 1 leads to the production of mono-disciplinary, homogeneous and organisationally hierarchical knowledge, the knowledge resulting from Modes 2 and 3 is transdisciplinary, heterogeneous, and transient. In these two more modern modes, people, culture and technology interact to catalyse creativity, invention and innovation across sectors and disciplines (Gibbons et al., 1994; Carayannis and Campbell, 2009). Gibbons (1999) refers to this phenomenon as a *"significant shift"* from reliable to socially robust knowledge.

As the methods of knowledge production within modern systems of innovation continue to evolve, the interaction between science, industry, policy (Etzkowitz and Leydesdorff, 2000) and society (Carayannis and Campbell, 2009) become increasingly dynamic and complex as well. This interaction promotes new and more transdisciplinary methods of innovation, collaboration and knowledge production and thus the co-evolution of these four systems.

Participatory design for shared visions
In the context of new and emerging areas of science and technologies, participatory approaches can help access the knowledge of a variety of actors (Edler and Georghiou, 2007; Geels and Schot, 2007; Loveridge and Saritas, 2009; Jørgensen et al., 2009). They encourage public reflection on potential ramifications of technological advances and include those social actors who would be affected long-term by the results of research and development. Social actors can become *"enactors of a technology area"* and develop and promote their shared visions of the future (Jørgensen et al., 2009). Coming from different backgrounds, participating actors can identify different specifics of the *"general"* unknown and break it into pieces to make it more accessible.

In this context, methods from participatory design can be used to integrate laypersons into the otherwise mainly expert-driven process of technology agenda-setting (Heidingsfelder et al., 2016), as opposed to established language-based methods, participatory design which engages multiple senses, promote interaction on multiple levels and encourages experimentation. Methods that enable making, telling and enacting (Sanders et al., 2010) help to engage laypersons as *"experts of their experience"* (Visser et al., 2005; Sanders and Stappers, 2014; Halskov and Hansen, 2015).They equip laypersons to fulfil a more fundamental role in the entire technology development process.

Within our project Shaping Future (2014-2017), we utilised methods from participatory design – such as storytelling, fictional identities, material speculation and prototyping – to enable people from a broad variety of social and professional backgrounds to explore and express their preferences for future technologies. We therefore organised a series of co-ideational workshops, focusing on potential future technologies in the areas of workplace, relationships, healthcare and transportation (more detailed described in Heidingsfelder et al., 2016). To analyse the workshop's results and to transfer them to technology specialists, we developed an interdisciplinary evaluation strategy that involves methods from the social sciences and from design research, particularly the method of explicative content analysis. A group of interdisciplinary scientists then estimated when proposed developments might become technologically feasible and arranged them on a timeline based on these estimates. Our results show that using material speculation and building speculative prototypes (so called "narrative objects") helped participants to develop and express their perspectives and visions. Furthermore, making thoughts tangible allowed them

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to step into an *"embodied speculation"* (Rozendaal et al., 2016); they could critically reflect on social and ethical implications and start discussions on potential developments.

Design fiction for public reflection
In the above-described socio-technical context, the goal of our project Shaping Future was to develop an innovative method of knowledge production and of public participation in agenda-setting processes. In addition to the project's participatory workshops, we developed and realised a public exhibition of design fiction prototypes. Our approach builds upon theories and concepts from design fiction (e.g., Bleecker, 2009, 2010; Sterling, 2009; Grand and Wiedmer, 2010; Blythe, 2014) and speculative/critical design (e.g., Bardzell and Bardzell, 2013; Dunne and Raby, 2013). In contrast with science fiction literature and films, design fiction and speculative design more strongly addresses contemporary issues. Dunne and Raby (2013, p. 100) describe critical design as *"a critique of the prevailing situation"* and as embodying *"alternative social, cultural, technical, or economic values."* Bleecker (2009, p. 4) regards design fiction as an opportunity *"to begin conversations that question assumptions"* about progress and the future. The lines between design fiction and speculative design are blurred and might be described by articulating different aims; while speculative design aims at providing a critique of the present, design fiction rather aims at exploring alternative futures.

Based on these theories, we define design fiction prototypes as designed objects that provide general *"drafts"* (rather than specific non-functional models of proposed technologies) and reach their final form only through interaction with the observer. In the context of uncertainty, we assume that their use can support public reflection on prospective technological advances and thus help uncover the unknown.

While speculation stands in contrast to clear and definite knowledge, it can shed light on the vast darkness of this unknown. Within the broad realm of the potentially possible, it can help identify particular paths by suggesting specific development scenarios. In the context of technological advances, such scenarios, regardless of how probable they are intended to be, can encourage a society to re-envision its ways.

A public display of speculative objects, prior to the development of specific technologies, can support public reflection on new and emerging areas of research and technology, particularly their potential social and ethical ramifications. As these objects are designed to engage inherent human senses such as sight and touch, their use can promote the desired reflection in at least three different ways. (1) As opposed to professional terminology, such *"tangible expression"* is accessible to most people and thus can help involve a broad variety of social actors and perspectives. (2) Such objects enable *"embodied speculation"*, which helps *"imagine, critically reflect [on], and engage in dialogue about"* social opportunities and ethical implications (Rozendaal et al., 2016, p. 100). (3) While these objects suggest certain functionality, they leave sufficient room for interpretation and ultimately inspire reflection on the desirable

"A public display of speculative objects, prior to the development of specific technologies, can support public reflection on new and emerging areas of research and technology"

methods of human-machine interaction including interfaces.

In this manner, design fiction can encourage an ongoing collaboration between researchers and other social actors in which they can share their diverse and probably often complementary knowledge. This process thus provides new methods of communicating science and promotes *"public engagement in science"* (Siune et al., 2009). While speculative design does not directly support technological advances, it can produce significant impacts by enabling engineers and researchers to synchronise these advances with public preferences. By also proposing a variety of futures, it can empower laypersons to co-determine the long-term trajectories of the technological future and thus provide a method of *"serious speculation."*

Additionally, Grand and Wiedmer (2010) argue that design fiction can promote not only public reflection but interdisciplinary collaboration. Because they encourage experimentation, methods of design can help researchers and engineers uncover the virtually unlimited inherent contingencies of the world and gain new insights, both within and across their particular disciplines (Grand and Wiedmer, 2010, pp. 5–6). They help transcend the limitations of specific terminologies or methodologies and transform diverse, and also intercultural, perspectives into shared visions. Finally, by providing a tangible presentation of proposed functionality, they can encourage engineers and researchers to focus their attention, not only on the science of prospective inventions, but also their design.

Case study: Public discussion of design fiction prototypes

During the final stages of Shaping Future, a number of design prototypes were developed and publicly displayed in order to explore how such objects can be utilised for the above-described purposes. These stages relied on the results of the previous ones, particularly those of *"lay"* workshops in which people from diverse (non-engineering) backgrounds were encouraged to co-envision human-machine interaction in the year 2053. The project team invited professional designers to select the idea that each found most interesting and to create a design fiction prototype manifesting that idea. The goal was to find the middle ground

between the laypersons' ideas, in all their originality and the practical considerations of the engineers. The project team therefore familiarised the designers with both and then remained available for advice. This process resulted in the following four objects:

- Human+ Carbon- (Johanna Schmeer) was a toolkit of wearable technologies which would reduce environmental pollution when applied to a human body and which could consist of bacteria or nanomaterials;
- Adaptive Environment (studio milz) proposed a method of creating architectural spaces with the help of genetically modified caterpillars;
- Gutmentor (Stefan Schwabe) suggested a method of capturing and transferring experiences and emotions (the so-called *"gut-feeling"*) with the help of microbiota capsules; and
- Healing Muscle Patch (Florian Born) was envisioned as a human enhancement technology utilising bacteria to administer vaccines and stimulate muscle growth.


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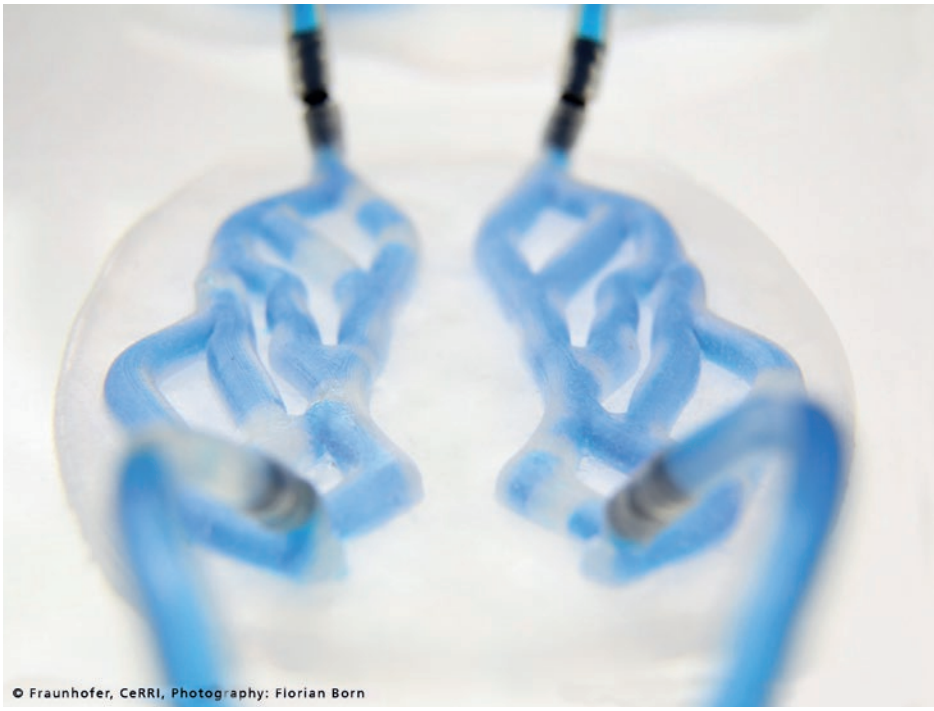
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To increase public dialogue and to address a diverse audience, these prototypes were exhibited for three months in an innovation space (JOSEPHS©) in the centre of Nuremberg, a large German city. Admission was free of charge and visitors were invited to give their feedback by means of a questionnaire, by talking to the guides and by rating the prototypes with an *"evaluation map"*. Furthermore, workshops were organised to allow a more profound involvement. Overall, 3.155 visitors attended the exhibition, 438 gave their feedback to one or more prototypes and 144 completed the questionnaire.

The results show that the design fiction prototypes provided a good starting point for public reflections: visitors could identify different types of social and ethical implications and develop a differentiated opinion by formulating conditions for implementations. They also proposed new areas of application for the presented technology and thereby provided an input for research planning and technology development. With regard to the content, the visitor's comments are very diverse and controversial, often even emotional. With respect to the *"Gutmentor"*, visitors' feedback included comments like: *"I think it's great, because it increases empathy"*, but also

critical statements like *"Emotions are private, you shouldn't be able to share them that way"* or "*People would forget to deal with their emotions"*. These findings show how public debates can be initiated and argued out by means of design fiction objects: they provide a tangible basis for the discussion of different perspectives.

On an aesthetic level, visitors rated the prototypes as innovative, interesting, futuristic and extraordinary. Their pointed visual presentation of potential future technologies could arouse interest for the (otherwise very abstract) field of new and emerging sciences and technologies. 46% of the visitors stated that the objects inspired them to think about topics they had never, or rarely, thought about before.

Last but not least, our exhibition shows that design fiction prototypes can also be used as *"probes"* for current and contemporary perspectives on new technologies. Their public discussion shows what kind of needs and acceptance thresholds exist, not only for future developments but also for present technologies, for instance in the fields of biotechnology, sustainability or *"intimate technologies"* (van Est et al., 2014).

Conclusions and further research

The technological future is subject to the unknown. This paper presented an original methodology intended to encourage public reflection on potential social and ethical ramifications and desirable outcomes of technological advances in the context of this uncertainty. The results of this reflection can enable researchers and engineers to align their inventions with public preferences and thus make these inventions more useful and welcome.

By proposing a variety of possible futures that can be directed and chosen between, design fiction can encourage collective reflection across specific fields and thus provide a new method of communicating science. In this manner, it can promote both *"public engagement in science"* and inter- and transdisciplinary collaboration, which are increasingly prioritised by research funding agencies.

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Because the approach is new, further research will be necessary to uncover its full potential. Promising areas for future study in the field of science communication include the ways in which scientific exhibitions, particularly of design fiction, can support participatory processes. Also worth exploring are which audiences can support these processes and how should such events be conducted so they can best reach diverse audiences?

Another interesting question is how design fiction can support the communication of knowledge, including knowledge about the unknown. An examination, from the design research perspective, of what can be expressed through particular attributes of speculative objects, might provide some answers.

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