

## Sensing Care Through Design

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**DOI**

[10.1145/3563657.3596066](https://doi.org/10.1145/3563657.3596066)

**Publication date**

2023

**Document Version**

Final published version

**Published in**

DIS '23: Proceedings of the 2023 ACM Designing Interactive Systems Conference

**Citation (APA)**

Rattay, S., Collins, R., Surana, A., Lee, Y., Liu, Y., Mauri, A., Urquhart, L. D., Vines, J., Wilson, C., Pschetz, L., Rozendaal, M. C., & Shklovski, I. (2023). Sensing Care Through Design: A Speculative Role-play Approach to "Living with" Sensor-supported Care Networks. In D. Byrne, & N. Martelaro (Eds.), *DIS '23: Proceedings of the 2023 ACM Designing Interactive Systems Conference Association for Computing Machinery (ACM)*. <https://doi.org/10.1145/3563657.3596066>

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# Sensing Care Through Design: A Speculative Role-play Approach to “Living with” Sensor-supported Care Networks

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## ABSTRACT

Sensor networks are increasingly commonplace in visions of smart cities and future healthcare systems, promising greater efficiency and increased wellbeing. However, the design of these technologies remains focused on specific users and fragmented by context, overlooking the diversity of needs, wants and values present when technologies, people, and lived realities interact within instrumented spaces. In this paper we present a workshop method – Sensing Care – that can help researchers, interdisciplinary design and development teams, and potentially affected users, to explore what it takes to design for living with sensor technologies that intersect and interact across private and public spaces, through speculative scenarios and role play. Drawing from three deployments of the workshop, we discuss how this approach supports the design of future care-oriented sensor networks, and helps designers understand what it means to live with complex technologies as people traverse diverse contexts.

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*DIS '23, July 10–14, 2023, Pittsburgh, PA, USA*  
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ACM ISBN 978-1-4503-9893-0/23/07.  
<https://doi.org/10.1145/3563657.3596066>

## CCS CONCEPTS

• **Human-centered computing**; • **Interaction design process and methods**;

## KEYWORDS

Design methods, location-aware computing, contextual computing, speculative workshop

## ACM Reference Format:

Sonja Rattay, Robert Collins, Aditi Surana, Youngsil Lee, Yuxi Liu, Andrea Mauri, Lachlan D Urquhart, John Vines, Cara Wilson, Larissa Pschetz, Marco C. Rozendaal, and Irina Shklovski. 2023. Sensing Care Through Design: A Speculative Role-play Approach to “Living with” Sensor-supported Care Networks. In *Designing Interactive Systems Conference (DIS '23)*, July 10–14, 2023, Pittsburgh, PA, USA. ACM, New York, NY, USA, 16 pages. <https://doi.org/10.1145/3563657.3596066>

## 1 INTRODUCTION

In the last few years, the city of Amsterdam has deployed over 200 cameras, around 230 air quality sensors, and almost 500 beacons throughout the city. Research projects at AMS, the Institute for Amsterdam Metropolitan Solutions, from “robo-boats” to “scan cars”, investigate how to integrate mobile sensors within urban spaces, perpetuating the vision of a fully connected, smart and aware city, optimized for the seamless coordination of mobility flows, energy infrastructure and management of city assets. At ACRC, the Advanced Research Center in the city of Edinburgh, researchers are working to embed machine vision sensors into the homes of older

adult citizens to enable remote health monitoring and diagnosis, using sensor networks to integrate personal care in medical communication procedures. While engaging in different settings, the visions associated with smart cities and connected homes paint pictures of urban and private spaces filled with helpful technology systems that assist people and take on the labor of maintaining wellbeing. However, there are growing concerns about the uncertain consequences for people inhabiting spaces instrumented with sensor networks [13, 14]. Researchers have grappled with privacy concerns [11] and value-tensions [20, 23] brought about by these technologies – tensions that are likely exacerbated when cities, homes and other private and public spaces are instrumented and networked alongside or with each other, and when people inhabit and traverse these different spaces.

Recently, researchers have turned to the notion of entanglement [21] to help understand the complexities of technologies like these, and how they eschew the idea of creating well-defined use cases around singular users. Frauenberger’s [21] notion of ‘entanglement’ places humans and things within a system of relations and interdependencies, focusing on the design of configurations of actors, interactions, and environments and understanding the relationships in-between. This re-orientation challenges simplistic conceptions of the user in HCI [7, 26, 47] through a shift of perspective from designing for ‘use’ of sensor networks towards designing for ‘living with’ sensor networks [38] and the relations between people, things, and environments [17, 21]. Given the ubiquitous presence of sensor networks, we are long past simply using such technologies in distinct and well-defined situations. When considering an expanded view of what ‘living with’ sensor networks implies, the level of complexity increases. Consequently, the idea of ‘living with’ has proved difficult to integrate into technology design practices, not least due to the complexities of technological entanglements within changing contexts of daily living, routine, and extended use. Adopting an entangled and relational way to understanding sensor networks prompts us to consider the situatedness of multiple actors (including the human and nonhuman), how desirable actions and interactions can take place, and how value tensions can emerge from the interdependencies between multiple actors. A broad consideration of values [23], and the tensions that may arise from conflicting ones [40], is important to understand the forces that operate within these interdependencies.

In this paper we present a speculative workshop method – Sensing Care – that can help researchers, interdisciplinary design and development teams, and participants, to explore what it takes to design for living with sensor technologies that intersect and interact across private and public spaces. In our work, we drew heavily on prior work on speculative enactments [17], an approach to exploring first-hand interaction and experience with participants through speculative design projects and fictional scenarios. The emphasis speculative enactments place on complex social contexts and the creation of scenarios with consequentiality for participants, means it is placed well to support inquiry into the entanglements with sensor technologies. We developed our adaptation of speculative enactments as part of an ongoing collaboration with two organizations working with sensor networks and associated municipal and in-home services, with a focus on promoting new forms and models of care in later life. In this context, we sought to develop a method

that could be used both with external stakeholders and internally within the organizations to break down the common silos between designers, developers, user researchers, data scientists, and others working on different aspects of the same technologies.

Our method brings together speculative narration and role-play as modes of engaged reflection and acting-through scenarios of relational conflicts, combining techniques such as timelines, design cards, and theatre, into one participatory workshop process. Carried out across three deployments with diverse groups of participants, the workshop process provided ways to surface tensions around roles and responsibilities in care sensing, eliciting insights into the contextual nature of trust and the importance of integrating public and private networks of care. In particular, we emphasized the contextual positionality of care and related values such as trust and privacy, bringing a relational dimension to current understandings of these values.

In presenting our method, we contribute an approach to designing for ‘living with’ sensor networks – and data-driven technologies more generally – in complex contexts that include changing and competing values and priorities such as care contexts. The method provides an accessible means to support citizen participants and diverse research and development teams to reflect on assumptions around use-cases and people related to their projects, enabling design teams to engage purposefully with value tensions and to re-envision the sociotechnical futures they are collectively working towards.

## 2 RELATED WORK

### 2.1 Sensor Networks, context, and entanglements

In his seminal text, the *Computer for the 21st Century*, Mark Weiser presents a future vision of ubiquitous computing where “the computers themselves vanish into the background” [55]. Weiser envisioned home, urban and workspaces which quietly attend to our needs, anxieties, and inefficiencies, while keeping the interface to a minimum. Cleaving to the vision of the ‘disappearing computer’, context-awareness has become a focus of much ubicomp research and practice [36], in urban navigation [49], for the mobility of older citizens [30], and as a means to maintain resident safety in cities [33]. Similarly, there has been a proliferation of many devices, services, and sensor-systems seen as solutions for the mission of active and healthy aging, automating provision of care through, for example, ambient assisted living [57] as a way to support aging-in-place.

Despite addressing very different contexts, smart urban and home systems encounter many similar challenges, from being (un)able to correctly interpret context, to being able to react to unforeseen situations [59, 60]. Smart systems can fail disastrously, such as when Tesla’s driverless car autopilot resulted in multiple deaths [50, 51] or when biased results from facial recognition software used by law enforcement resulted in erroneous arrests [27]. Although death and incarceration may seem far removed from an errant smart home sensor, the underlying intentions, technologies, and systems used are all a part of contemporary ubiquitous computing, its messiness, and our entanglements with these systems. Issues in these underlying frameworks, algorithms and data acquisition methods [24, 29, 31] point to an unaddressed need to engage



with intertwined social contexts and to be adaptable to contexts yet to be encountered.

Sensor networks as context-aware systems directly challenge the idea of who the user is and how to account for the other “out there” [10, 49]. Positioning the user as central has inherently normative implications for how design processes around these systems unfold [6]. Current instantiations of sensor networked systems attempt to understand contexts and situated interactions through constant data collection, which affects everyone within the vicinity of sensors and poses challenges to notions of consent, trust, and privacy. Yet design typically focuses on direct users, doing little to account for those who do not directly own or control the systems monitoring instrumented spaces, such as guests, passers-by, and other temporary stakeholders [3, 8, 60]. Ideas and visions of the ideal user draw attention away from the cases in which ubiquitous computing encounters situations and contexts where people do not fit with the expected ideals, resulting in overlooked and under-designed scenarios unable to grapple with the relational complexity of shared spaces [14, 26]. Accounting for these complexities requires design methodologies which acknowledge and embrace diversity rather than attempting to control and homogenize it [26].

There is much agreement that design involves making normative judgments about values, which come to be inscribed in technology [4, 32], highlighting the need for designers to be reflective of, and responsive to the normative impacts of their practices. We focus on ‘living with’ sensor networks, where value judgments are implicit in how to enable such technologies to support interactions and user experiences that are experienced as ‘living well’. Values, such as privacy, trust, or care, manifest differently depending on the situation. The value of privacy, for example, is not abstractly defined or absolute, but instead depends upon maintaining expectations and contextually appropriate interactions between humans, technology, and the flows of information [44]. These contextual shifts are important when considering not just designing for the abstractions of values but designing for values as these are enacted in life, when people live with technologies.

While the notion of entanglement incorporates attention towards value enactments, the question remains how to operationalize these in design practice and what form reflections on embedded values must take when addressing the challenges in the design of sensor networks. To move away from the focus on the user and interactions between the user and their technologies, we need to develop methods that foreground the depth of factors and forces that affect ‘living with’ technological systems. Designing for entanglements is to “leave user-centered design behind and develop agonistic, participatory speculation methods to design meaningful relations, rather than optimizing user experiences” [21]. When designing for large networks of ubiquitous sensors, this notion of entanglement foregrounds the fluid interdependencies that are often presented as unintended consequences to an inherently isolated user-device experience. One way of doing this is by incorporating notions of care, care relations, and care networks into technological development.

## 2.2 Care entanglements

In our work, we are collaborating with partners who are interested in applying networks of sensors to develop solutions for in-home

care and municipal services. As such our work connects to a long-standing body of work on the development of ubiquitous computing systems to care services [28, 35]. Despite increasing attention to the notion of care in HCI, care remains a difficult term to define. Within ambient sensing environments, and especially where these spaces purport to care, Frauenberger calls for abandoning the notion of user experience entirely and instead designing for relations. In this paper, while care is a service domain of interest, we also ground our work in broader definitions and explorations of care that aligns with the notion of entanglements. We follow the definition of Fisher and Tronto [19], viewing care “as a species activity that includes everything we do to maintain, continue, and repair our “world” so that we can live in it as well as possible. That world includes our bodies, ourselves, and our environment, all of which we seek to interweave in a complex, life sustaining web.” Such an open-ended conception of care connects with the notion of entanglements, acknowledging the fluidity of relations between actors. The logic of care [41] recognizes that what counts as good or the ideal of a good life is not fixed, but contextual, fluid, and personal.

Care practices have been translated through design experimentation to many contexts, including healthcare and public space [34], as well as democratic inquiries in ways to design for relationships between communities and institutions [15, 35]. To address anxieties around the uncertainties of sociotechnical innovation, institutions are investing in responsible research and innovation efforts, in order to responsively take care of the future [48]. Rights- and risk-based frameworks attempt to ensure the protection of values of perceived importance, such as privacy, independence, and autonomy, centering people as autonomous and independent individuals who can make informed decisions about technology use given sufficient information. This perspective puts impossible responsibilities on people as they make decisions about technology [16, 18]. In contrast, the logic of care positions people in relation to each other, entangled in networks of varying needs, relying on each other to make decisions, and embedded in time [41]. Yet care is also political. To care means to judge about whom to care for, how, and to which extent [37], often leading to value-tensions [58] and conflict. This implies that context-aware systems that instrument environments must make space for uncertainty, tensions, and conflict in order “to imagine a world organized to care well” [53].

## 2.3 Using enactment to design for entanglements

Speculative and critical design work has engaged with notions of care and entanglements through a variety of provocative interventions. Speculative design has a tradition of creating provocations and openings to think about futures and to critique current practices [5], with recent projects engaging audiences by focusing on the limitations and possibilities of everyday life [12, 20]. Efforts to involve participants as co-creators have led to participatory forms of speculation such as Critical Play [25] and Participatory Design Fiction (PDFi) [43], bringing attention to messy and conflicting values in real contexts. Some of these approaches have utilized role-play methods to engage diverse stakeholders such as users, providers, decision-makers, and design researchers [17, 54]. Researchers have also explored ‘live’ theatre methods to create shared

and embedded learning about the complexity of social values such as care, privacy, and trust through acting within designed possible near futures [47, 54]. The use of theatre techniques such as improvisation in design workshops offers an entry point to ‘unfinished’ future situations which can help to create openness for participants [39], enabling designers to prototype compelling and dramatic future situations by embedding participants’ own values, experiences and concerns [46, 47, 54].

Building on this range of speculative design and scenario-based design approaches, Elsdon et al. introduced the notion of speculative enactments, which focus on stage-setting and interventions situated in everyday scenarios, to provide for “grounded, but unscripted improvisation of particular futures” [17]. Speculative enactments build on role-play approaches, with each enactment guiding participants through carefully orchestrated experiences of mundane future scenarios. However, speculative enactments lean on leading participants through a critique of a defined scenario, constructed by the design team. Similar to many role-play methods, speculative enactments can be quite constrained [54], in an attempt to enable participants to grasp and relate to the experience that have consequentiality [17] for their own lives. Light [34] distinguishes between more democratic speculative practices and those that are more designer controlled. She calls for approaches that seed rather than lead and may offer glimpses of a range of futures, which allow participants to go in many directions. Inspired by the long tradition of role-play and theatrical techniques in design settings, and the more recent work on speculative enactments, we sought to create a method that can seed [34] participatory enquiry into future technologically mediated entanglements around care, situating participants in a future imaginary.

### 3 RESEARCH CONTEXT

The project was initiated as part of a research program between a selection of European universities and industry partners. We worked with two different organizations that develop technical systems based on a range of sensor technologies. Located in Amsterdam, Amsterdam Metropolitan Solutions (AMS) develops sensor networks to help the city become more efficient by supporting optimization of mobility flows, energy infrastructures, and management of city assets. The Advanced Care Research Centre (ACRC) in Edinburgh is working to embed machine vision sensors into the homes of the older citizens with care needs to enable people to live more independently in their own homes. Despite their differences, these organizations rely on similar ideas of instrumenting public or private spaces using emerging sensor network technologies. Due to the inherently invasive nature of embedded sensors, both organizations expressed worries about how future services might address privacy concerns and remain trustworthy. The organizations were seeking future-oriented methods that could enable them to explore notions of trust and privacy through anticipatory scenarios and user-centred explorations.

#### 3.1 Industry Partner Interviews

To develop an understanding of our collaborator’s needs, we conducted fifteen in-depth interviews over the course of two months with domain experts involved with AMS and ACRC. We selected

our interviewees based on their complementary perspectives on sensing networks. At AMS interviewees included citizen scientists, interaction designers, technologists, and city legislators. At ACRC interviewees included healthcare practitioners, nursing studies scholars, social scientists, and technologists. While AMS and ACRC both expressed interest in broad exploration and speculative design work, neither had been able to find productive ways to implement these aspects in their current work practices.

The first five co-authors reviewed and discussed all interviews, conducting iterative, thematic analysis throughout the research process [9], thus ensuring that new interviews helped build on the understanding gained from prior interviews. Throughout the interviews, industry partners expressed worries about reinforcing oppressive structures through the implementation of their technology, and how to build awareness and sensitivity towards these dynamics. They were not just worried about how to get the implementation right, but also how to not make other matters worse. We identified four primary concerns: *multiple voices and actors*, *interdependence*, *situatedness*, and *performativity*, which provided a framework for our design process.

**3.1.1 Multiple voices and actors.** Both organizations aimed to design products and services fitting the imaginaries of a world well-equipped with sensors in the service of citizen or patient care. Many interviewees explained their concerns around the potential unintended consequences of their work in relation to more abstract political and social issues, such as enabling sociability while respecting privacy for people in their homes or providing just-in-time services in a GDPR-compliant way for the citizens. The need to address multiple voices and actors holistically and to attend to interdependence, emerged as we observed the strong fragmentation of research and engineering efforts in both organizations.

**3.1.2 Interdependence.** Technologists and designers involved in producing these systems described a general sense of uncertainty in how to engage productively with systems that can be situated in, and traverse between a variety of use contexts and the value tensions that can arise from it. Very few considered the interconnections between the technologies they were researching and building, and the broader assemblages of human, non-human, and technological actors that already inhabit the contexts they imagined instrumenting. There was a keen understanding that engaging stakeholders (people, service providers, and municipal organizations) is important for bringing about positive technological futures, but how to address a multiplicity of voices and actors, going beyond the traditional stakeholder consultation orientation remained a considerable challenge.

**3.1.3 Situatedness.** The stakeholder engagement approaches practiced by both organizations appeared limited to high level and general conversations between teams. Few of the envisioned and researched technologies are yet implemented in the scope and breadth that AMS and ACRC are working towards. Instead, they were able to offer high-level abstractions and vague potentials, which remained disconnected from the lived experience and blurry in their consequentiality. Yet ‘living with’ technology is necessarily situated and contextually defined. The challenge then is how to access and assess situatedness when imagining future technologies.

**3.1.4 Performativity.** Both organizations also expressed frustration with their inability to explore how complex interdependencies created by sensor network implementations could be experienced. After all, it is difficult to imagine what expression might a privacy violation or a contextual response failure take on in practice. As such, performativity in speculating futures emerged as an important requirement.

### 3.2 Author positionality

Given the complexity of our topic of inquiry and many diversity and justice considerations embedded within speculating technology futures, it is important to clarify author positionality. Speculative and critical design projects have been criticized for claiming to provide provocations of potential futures, while disregarding the uncomfortable and political implications of the systems they are critiquing at present [45]. Particularly questions of gender, race, and class are rarely considered in these speculations, while dystopian notions that are raised as warning about potential futures can overlook the fact that certain groups of society are already facing these at present. This is particularly important for matters of care, which are traditionally fraught with tensions of power. Systemic structures acknowledge certain kinds of care and certain groups of carers, while disregarding the contributions and needs of others, typically outside of a white heteronormative male norm. Speculative design is affected by similar dynamics as other design practices, which, if not confronting issues of political power imbalances intentionally, can skew towards supporting a status quo of present discrimination within their future envisionings [52]. While the content of our workshop method was heavily affected by the imaginings and needs expressed by our industry partners, situated as they were in a Western European context, we worked to ensure that questions of power were surfaced within the speculative process.

The research team represents different intersections of nationalities, ages, races, genders, cultures, and first languages and come from different countries, both within and outside of Europe. Given that the partner organizations were located in Western Europe, our approach to interpretation was Euro-Anglo-centric, although we were conscious that notions of ‘care’, ‘trust’, and ‘privacy’ are shaped by cultural and geographical factors. The researchers have prior experience working in design and/or creative industries with diverse publics, sensitized to the multiplicity of participant experiences. While this project did not involve a specific intersectional focus, particularly with ‘care’, the researchers are actively exploring and applying these concepts within their own research agendas. Our focus on interdependence and multiplicity of voices, which formed part of the foundation for the design of the workshop method we propose here, offers possibilities for direct engagement with concepts of design justice and intersectionality.

## 4 TOWARDS A SPECULATIVE WORKSHOP METHOD

The four primary concerns of multiplicity of voices, interdependence, situatedness, and performativity, that we identified in our work with industry partners ACRC and AMS, formed the foundation for developing a usable approach to collectively exploring the

future of instrumented spaces with a variety of stakeholders. Operationalizing the experience of ‘living with’ sensor networks from a relational and entangled perspective was central to the design of our workshop method. Drawing on a range of design techniques, specifically speculative enactments [17], critical play [25] and participatory design fiction (PDFi) [43], we sought to bring together a multiplicity of voices and perspectives from diverse participants and domain experts, providing a ground for situated and performative exploration of interdependencies and value tensions emerging with and through future sensor network implementations. We provided an infrastructure that is open enough for varied input from stakeholders, as well as for exploration and reflection by designers themselves, to explicitly raise and highlight the technical and social aspects of their concern with each other. Our method includes scenario-based role-play workshops with two main components:

- A fictional narrative in the form of a speculative timeline, which captures different research and innovation endeavors by the partners and future visions of products and services underpinned by these, as well as social and political trends surrounding these future visions (FIG 1)
- A card-based role-play that enables participants to speculate on scenarios within care networks in this fictional future, by inhabiting human and non-human technical actors such as sensors. (FIG 2 and FIG 3)

The novelty of the method lies in the adaptation of two familiar approaches to fit into contexts that span care-related concerns across private and public spaces. Our adaptation of existing approaches within a care context also contributes to a discussion on variations of these approaches (e.g. by providing a comparison between the involvement of actors and designers enacting the technology as explained below) and the need to balance portability and precision to make such methods widely accessible. Our specific approach allows involvement of both potential users and experts in the same workshop, thereby facilitating a conversation that can flow both ways. It can be used both with external stakeholders and internally within the organizations to break down the common silos between designers, developers, user researchers, data scientists, and others working on different aspects of the same technologies, providing an approach to participatory speculation that aligns well with the demands of contemporary industry research and development settings.

### 4.1 Building a fictional tech future – developing the timeline

Building on work by Wong & Nguyen [56] and “2038 The New Serenity” [1], we developed a speculative future-oriented timeline of key consequential events as a starting point for contextualizing a world where the scenarios with technology might take place. Starting from the year 2022, the timeline links a collection of potential societal developments into a narrative that balances both positive and negative fictional news stories, connecting economic factors with political trends and technological developments towards a future of smart environments. The timeline was visualized in the form of news headlines, accompanied with corresponding images for each item (see FIG 1).

A key concern for engaging with the contexts of our collaborators was the perceived consequentiality of the workshop experiences for all types of participants. Consequentiality can be supported by carefully constructed scenarios that have social consequences for participants in the moment [17]. As such, we grounded our timeline in issues and concerns brought up in industry partner interviews, noting that similar topics of technological development, politics, business, and healthcare emerged across both organizations. We collected prominent concerns, predictions, and assumptions around these topics, framed them as individual news items, and linked them into a progressive narrative. For example, a discussion about sensing technologies and mental health with an ACRC researcher inspired the story item from the year of 2024 entitled “The new tech frontier: mental health” (see FIG 1), which illustrates a push within tech companies to integrate mental wellbeing into their service portfolio. This story item also signals another story item from the year of 2026, in which a governmental study has identified automated care for mental illness as a source for increasing loneliness.

The function of the timeline is threefold. Firstly, it enabled us to navigate different levels of care relations and to define ‘care receivers’ and ‘care givers’ more broadly: ‘care givers’ in our work include informal caregivers as well as professional care experts, decision makers such as municipality governments, and capitalist agents like insurance providers and technology companies. Secondly, it facilitated the recursive conversations between our team and the collaborating organizations. These conversations reinforced a contextual view of sensor-enabled interactions and value tensions. Finally, it served as a narrative device that situated the workshop participants in a speculative future. The details and tonality of the accompanying texts also provided participants with reference points helpful for the role-play.

The timeline is deployed at the beginning of the workshop, where a facilitator narrates it in the form of a news broadcast, setting the scene by eventually taking participants to the year 2032. Participants were then guided to the next steps of the workshop, working within the future sketched by the timeline.

## 4.2 Role-play materials

We used role-play to engage diverse stakeholders who have different interests and purposes, allowing participants to embody designed future situations by acting them out [39]. We focused on group settings, creating four sets of cards to facilitate dialogue and critical enquiry amongst participants and to support the role-play activity. Cards have a long tradition of being used as design prompts and catalysts in workshops [2, 22]. We designed our cards based on the inputs from industry partner interviews, where care experts and technologists shared stories from their research and experiences (see Section 3). For example, care experts provided input on the importance of different relationships between care receivers and caregivers, while technical experts described disruptions that challenge integration of their technologies into different environments.

The four sets of cards provided scaffolding and storylines for the scenarios that formed the core of our workshop and introduced

controlled moments to guide the improvisation, enabling performativity. Set 1: defined the situations in which the enactment is played out, focusing on the situatedness of experiences with technology. Set 2: defined the characters that participants play, which can be either human or nonhuman, enabling participants to engage with a multiplicity of voices. Set 3: presented disruptive events to prompt reactions and require improvisation from the actors, acutely demonstrating life’s many interdependencies. Set 4: presented values that helped participants reflect on the socio-ethical implications of technologies they imagined. Combining the card sets helped participants imagine, play out, and embody the scenarios that emerged and reflect on the value tensions they experienced. In the following we describe the sets in more detail, the full set can be viewed in the supplementary materials.

**4.2.1 Card Set 1: Situations.** The Situation card set consists of 8 cards describing settings in which the speculated future interactions could take place, giving the improvisation a starting point. We took into consideration relational variations regarding closeness, responsibility, and situatedness. This resulted in familiar and unfamiliar, private, and public settings (see Table 1).

**4.2.2 Card Set 2: Characters.** The Character cards set consists of 17 roles, including both human and non-human characters. With their different capabilities, responsibilities, and relational histories, these characters demonstrated the intricacy of care entanglements and provided concrete starting points for the role-play (see Table 2). We differentiated between formal caregivers, such as doctors and nurses, and informal caregivers, such as family members and friends, to explore how care can be experienced differently. Bystanders, passers-by, and neighbors might also find themselves in situations in which they unexpectedly have to provide care. We also varied the familiarity and relational history participants might have with each other and particular technologies. For example, distributed urban sensors such as smart traffic lights would typically be less familiar than smart-home technologies such as voice assistants or smart pets, even if participants never had direct experience with either. It is perhaps easier to imagine how one might want a smart pet to function, rather than a smart traffic light, whose context can feel more alien even if we encounter traffic lights routinely. The workshop structure was designed to accommodate one care receiver, at least one care giver (though more were possible if the role play evolved to require these), and at least two non-human characters.

**4.2.3 Card Set 3: Disruptive Events.** *Disruptive Events* consists of 8 cards that cover both disruptive technical and health incidents, whose purpose is to trigger ad-hoc improvisations and negotiations (engendered in a performative understanding of technology). The events include four hardware or software related interruptions for sensors: *false prediction*, *system updates*, *energy cuts* and *connection failure*, as well as four disruptions in the care receiver’s physical and mental conditions: *fall*, *critical health condition*, *confusion*, and *sudden routine change*. Events signal a shift in previously established care relations and create additional dependencies, prompting involved *characters* to decide anew what is appropriate and how to react given the changed parameters of the *situation*.

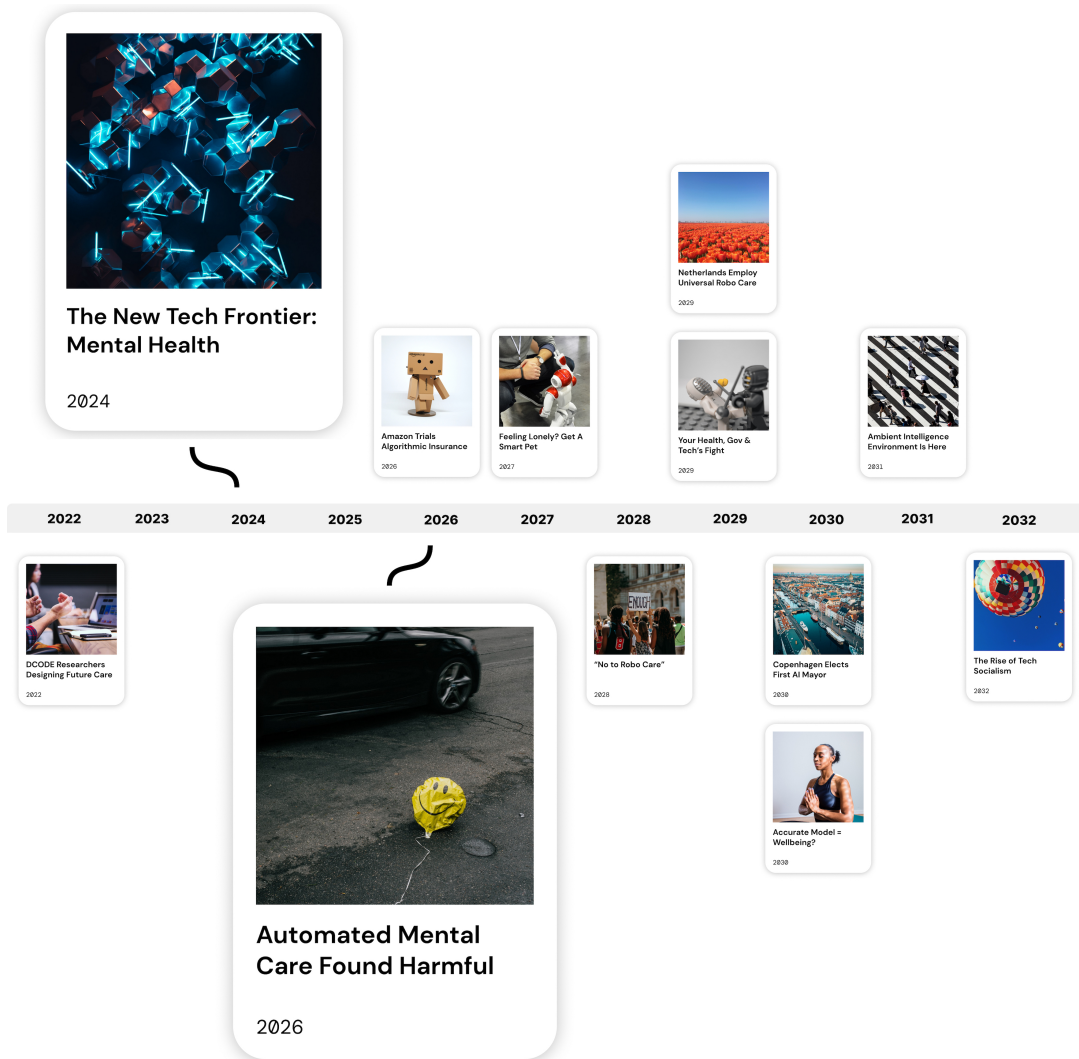


Figure 1: Timeline of speculative news items

Table 1: Overview of Situations

	Private	Public
Familiar	At Home: Friend Visit, Cooking Dinner	Outside of the home: Daily Walk, Family Gathering
Unfamiliar	At a private but unfamiliar space, such as a doctor’s office or a gym: Health Check Up, Working out	In an open and shared space: Shopping, Traveling

4.2.4 Card Set 4: Values as Keywords. The Keywords cards set consists of four cards: privacy, trust, reciprocal care, and empathy. These capture themes of contention. *Privacy* and *trust* were elusive concepts for our industry interviewees when it came to sensor system implementation, while *empathy* and *reciprocal care* were recurring points of discussion when they reflected on the support the sensors were supposed to provide to patients and citizens. *Keywords*

cards provide a connecting thread for the *situations*, *characters*, and *disruptive events*, offering for reflection upon the emerging tensions in the role-play. These cards can be related to any part of the workshop materials and act as connectors to draw discussions and reflections.

**Table 2: Overview of Character Options**

	Without relational history		With relational history	
	Informal	Formal	Informal	Formal
Human	Passer-by, Neighbour	Paramedic, Police	Family Member, Friend, Care Receiver	Doctor, Nurse
Sensor	CCTV, Smart Traffic Light, Crowd Sensor, Environmental Sensor		Smart Pet, Wearable device, personal AI assistant, Sensing Surface	

**Table 3: Overview of the workshop structure across two versions. The versions differ in step 3, with a different order of choosing characters and situations, and step 6 and 7, with the inclusion of the director in the speculative role play version. Highlighted in bold.**

	Live Theatre Version	Speculative Role Play Version
Step 1	Introduction and short discussion about prior experiences with tech and sensing devices	Introduction and short discussion about backgrounds
Step 2	Narration of the timeline	Narration of the timeline
<b>Step 3</b>	<b>Role-play set up: participants decide on their roles from the character cards and select the situation together. Actors select their roles accordingly.</b>	<b>Role-play set up: The audience splits into participants and spectators. One participant selects the role as care receiver and selects a scenario. The other participants select their roles accordingly.</b>
Step 4	Participants begin role-play by introducing themselves in their new roles and describing why they are in the scene. Facilitator sets the scene.	Participants begin role-play by introducing themselves in their new roles and describing why they are in the scene. Facilitator sets the scene.
Step 5	Participants begin improvising the situation and their actions within it.	Participants begin improvising the situation and their actions within it.
<b>Step 6</b>	<b>The sensors and the facilitator introduce events</b>	<b>The director introduces events</b>
<b>Step 7</b>	<b>Facilitator ends the role-play and introduces keywords.</b>	<b>The director ends the role-play. The facilitator introduces keywords.</b>
Step 8	Discussion and reflection upon the unfolding scenario.	Discussion and reflection upon the unfolding scenario.
Step 7		The participants and audience switch roles, and repeat the role play with new characters and scenario.

### 4.3 Workshop structure and variations

Our engagement with industry partners made clear that our method had to address two distinct but related needs. First, both organizations were interested in finding new ways to encourage and support speculative explorations of sensor network technologies with their potential users. Second, they were also struggling to develop a shared understanding of the kinds of issues their future users might encounter.

Most speculative design approaches support and facilitate the potential user engagement process to different degrees, but few turn their attention to the designers and developers themselves. By developing a method that could be used with different types of audiences, we sought to enable a deeper understanding of the potential challenges and concerns that affected citizens might voice, by engaging design and development teams in a low threshold workshop. Working with the four primary concepts from our domain expert interviews – multiplicity of voices and actors, interdependence, situatedness, and performativity, we developed two versions of the workshop that could engage both groups, using the same materials: 1) The first version used a live-theater approach to address variability in background knowledge among non-expert participants

necessary to effectively role-play non-human actors [54]. Since improvisation on the spot is a skill that might be more difficult for people without acting training but was crucial to explore tensions within the scenarios, we involved professional actors who could take on the role of sensors. This lifted some of the burden of narrative development from other participants, enabling them to focus more on the embodied reflections as tensions unfolded within more familiar human actor roles. This version enabled greater control by the facilitators and afforded greater familiarity to participants with situations and characters from which to speculate. 2) The second version leans on speculative enactments [17] without the involvement of trained actors, which allows inclusion of more participants and enables a more flexible circulation of characters. This version enables greater variation in speculations of sensor behavior and allows technology and design experts to explore the context of the technologies they imagine in a new way. The workshop structure and its variations are described in Table 3.

*4.3.1 Piloting with domain experts at AMS and ACRC.* The design of the workshop and the materials were piloted in walkthrough sessions with experts from AMS and ACRC over the course of two weeks. At AMS, we ran two sessions with design researchers,





**Figure 2: Pretesting the materials with stakeholder experts.**

design practitioners and data scientists, engaging six people in total. At ACRC, four testing sessions included design researchers, care researchers, and experts from a Public and Patient Involvement (PPI) group. The PPI group included people aged 55 – 70 age, whom ACRC has recruited as expert users for care focused research projects. Testing sessions including academics with experience in care research, data scientists and engineers, design researchers and 12 domain experts with diverse backgrounds in technology, business, care, and more, engaging 22 people in total.

The pre-testing clarified the order in which to introduce the *Character*, *Situation*, and *Disruptive Event* cards, and how instructions for the role-play should best be communicated. For example, the initial set up assumed participants would draw the cards randomly. The pre-testing showed that while this created playful scenarios it did not feel very co-creative and took steering power away from the participants. We therefore introduced a gradual construction process for the scenarios, where participants chose cards according to the choices made by other participants. Thus, the first component of a scenario is the scene, which is chosen by the person playing the care receiver, to allow them more control over the situation they will be vulnerable in. The other participants chose roles given the situation. We validated the importance of the *timeline* as a future-framing device and assessed the amount of facilitator involvement required to support participants with different levels of technical knowledge. Most importantly, we found that more scaffolding and care was necessary to introduce the vulnerable matter of care situations to address potential unease and discomfort.

**4.3.2 Live-theatre variation – citizen participants engagement.** The live theatre variation was tested in cooperation with AMS and relied on professional actors with experience in embodying technologies for design theatre involving older adults. Prior to the workshop, we shared a detailed workshop structure, the timeline, cards, and a description of traits of all nonhuman characters in the card set with the actors. Additionally, we met the actors online for further questions and explanations, focusing on character beliefs. Each of the eight sensor characters included in the cards was given a general description and indication of its relationship with the care receiver. The Smart Pet, for example, is a passive or active robotic companion who senses and provides comfort. We provided simple props for the workshop itself, expressing one main characteristic for each sensor. For instance, a cat ear headband served as a signifier for the Smart Pet. We created an environment that we furnished with simple but homely accessories. The furniture and accessories were modular so that participants could quickly configure the space as needed for the scenarios to support their enactment. We ran one 2-hour workshop with two participants and two actors, playing out two scenarios and a reflective discussion. Here we focused on personal experiences of care through collaborative speculation of imagined technology by involving actual potential users in the performative envisioning and prioritizing their contribution from the standpoint of the potentially affected. Participants focused on acting out how they would relate to and interact with the imagined technologies and focused on their own responses by drawing from personal experiences from the past as well as articulating concerns or hopes for the futures given the visions of supportive sensor networks presented in the timeline.

**4.3.3 Speculative role-play variation – engaging diverse groups of designers and developers.** In the speculative enactments variation, all characters (both human and non-human) were acted out by participants, typically with at least some background knowledge in design and sensor technologies. Given the diversity in experience and age of the participants in this variation, everyday care needs and perspectives of health were treated more generally. The underlying dynamics of care - accepting vulnerability, experiencing potential power hierarchies, discomfort with one’s own body - are present for everyone in situations of need. Yet these experiences can differ radically, depending on participant background, the nature of the situation, and the choices other participants make. This variation allowed participants to explore dynamics of care in relation to the imagined technologies that are part of the envisioned future sensor networks. To account for potentially a bigger group size in this variation, we introduced the role of ‘spectators’ and the role of ‘director’ to call the events and the end point of the role-play. Depending on the size of the group, the workshop can take up to 2.5 hrs to complete but requires at least an hour for a full experience with a small group. To test this format, we conducted two workshops with design researchers and design professionals at an event in Delft, Netherlands. In total 18 participants joined the two workshops, playing out two scenarios in each. We felt that the diversity of these participants enabled us to test whether professionals with different backgrounds and modes of engaging with sensor technologies in their practice would be able to productively engage each other through the workshop.

## 5 LEARNING FROM SENSING CARE APPROACH

The immersiveness of our workshop environment (actors, prompts, scenario, timeline) and the clear structure and timing helped participants embed themselves into the concepts quickly and encouraged roleplay. In the following sections we present short vignettes from each workshop variation to describe the participant experience. We then discuss the insights gained from the workshops to demonstrate our methods effectiveness. Finally, we report on reactions to our findings from industry partners.

### 5.1 Live-theatre variation – When traveling fails to happen vignette

The live-theatre session was conducted in Amsterdam, the Netherlands, with two invited older participants, who were recruited through AMS. Participants were P (61, female), a retired IT worker, and J (73, male), a retired care worker. Two professional actors took on the roles of the nonhuman characters. During the session, the actors wore plain black clothing and accessories such as a camera or sunglasses to signify their ‘thing actor’, enabling a clear distinction between human and non-human characters. The workshop space was set up as a living room, with a round table holding a few household items such as a vase. The printed news items from the *timeline* were displayed on the wall as well as handed out to participants.

The workshop started with a round of introductions of the participants and facilitators, as well as the project and workshop agenda. To familiarize the participants with the topic, the facilitator asked about their relationship with technology and sensing devices. Another facilitator then narrated the *timeline* in the form of a news broadcast, which eventually took participants to the year 2032. Situated in this future, we started the first round of the role-play. P volunteered to play herself, a care receiver, while J played the role of a neighbor (see FIG 3 right). Participants chose a *Traveling* card for the main *Situation*. The actors then selected their own nonhuman characters that were relevant to the setting. One played a *Wearable Device* and the other played a *Crowd Sensor*. The facilitator distributed props for the actors: a small camera for the *Crowd Sensor* and a string was attached between the wrists of P and the actor playing the *Wearable Device*. The actors and participants were then invited to reintroduce themselves as their new characters and to describe how they fitted into their scenario. The facilitator expanded on the situation and set the scene for the participants as a walk to the beach.

The participants settled into their roleplay by taking positions matching their starting situation - the actor playing a crowd sensor position standing on a chair to represent height, while the actor representing the wearable stood close behind P. P and J stood facing each other. As participants began to explore their characters within the situation, it turned out that J thought they were outside, while P believed that they had not left home. Consequently, the *Crowd Sensor* actor reverted to being a *Smart Pet* to fit back in with the changed scenario at home. P quickly asked for her *Smart Pet* and began a conversation with it. The neighbor, played by J, also talked with the pet. They discussed going out for a trip and bringing the pet. The *Smart Pet* warned that its battery was at 55%, introduced



**Figure 3: Top: Roleplay workshop with two older adults and two actors. The materials are displayed on the wall in addition to being handed out at the table. Bottom: Card selection for “When traveling fails to happen”**

the challenge of traveling with battery powered devices. The *Smart Pet*'s battery status and reminders caused some stress for the owner P. The *Wearable Device* suggested more conversation as a calming method. P said she felt a little overwhelmed by too many notifications and concerns – “too much control”. She finally decided that she wanted to be alone with her pet – but said “don’t touch me if I don’t ask for it” – and watched TV. She asked the neighbor, with some guilt, to leave, with an opening for more interaction in the future. The *Wearable Device* announced that P’s blood pressure began to drop.

A facilitator called an end to the scenario and introduced *Keyword* cards to begin a reflective conversation. After the discussion, we repeated the process for a second round of role-play with different situations and characters. The workshop concluded with a general discussion.

Allowing participants to play themselves as specific familiar characters helped them embody their roles and lowered their inhibitions within the role-play activities. Once the role-play scenarios had been defined, the interactions between the participants and the actors took on a life of their own and only needed to be occasionally steered by the introduction of the *Event* cards. The use of professional actors in the roles of sensors allowed us to involve





**Figure 4: Top: Concluding round table discussion of the role play variation with a larger group. Bottom: The card selection that was chosen to construct the Scenario “Pizza and Ambulance”**

older adults with no professional knowledge of technology without asking for too much improvisation in unfamiliar terrain. This created a space for elicitation of personal stories and lived experiences within the workshop. The reflections on the role-play provided a critical forum for the participants to speak about their experiences of the scenarios and triggered references to lived experiences which were similar or contrasting. Participants also shared their feelings about how they interacted with the technologies they encountered which led to the reviewing of personal experiences from alternative perspectives. These exercises surfaced many of the deeper concerns that were glossed over during the role-play itself and offered access to the more long-term issues in the design of caring systems, and deeper worries of the participants about how they might experience the need for care in the future.

## 5.2 Speculative role-play variation – pizza and ambulance vignette

The workshops were conducted at TU Delft with an audience of designers and technologists visiting the university for a design event. We began with an introduction and timeline walkthrough, in which the facilitator invited participants to close their eyes as the timeline was narrated. Transposed to the year of 2032, the group was divided into two subgroups, with one subgroup taking on the

characters and playing through a scenario, with the other observing, and potentially joining as additional characters when needed.

A participant volunteered as the Care Receiver and selected the situation Friend Visiting. The ‘care-receiver’ then expanded the situation as a friend visiting their home for a pizza dinner – and selected the character they wanted to roleplay with – the Friend. Other participants volunteered for the role of Director and the non-human characters as actants in the story – a Smart Pet (cat) and a Personal AI Assistant (see FIG 4). The seating arrangements were quickly adjusted to reflect the imagined space of a kitchen by moving a table into the center and drawing a quick mock up of a stove top on a large sheet of paper. Chairs were positioned to be kitchen stools and a fridge. The ‘care receiver’ and the ‘friend’ took position in the kitchen, with the ‘personal AI assistant’ taking position towards the side, and the role-play began.

As the Care Receiver and their friend were making pizza, the Personal AI Assistant interjected with a request for healthier toppings such as spinach. The Smart Pet quietly observed. The Director selected the Power Cut event card. The Smart Pet voiced its concern about recharging and the Personal AI Assistant warned of its low battery level, which introduced stress to the Care Receiver. Meanwhile, the friend suggested that the pizza oven might be gas powered and unaffected by the power cut.

The Director then selected a Critical Health Condition event card. The Care Receiver felt weak in the kitchen that became too hot. The Director suggested that the Friend might call an ambulance. The Personal AI Assistant stepped in and suggested calling for an ambulance before its battery got too low. The Smart Pet, detecting the word “ambulance” being spoken, also summoned medical help due to its programmed duty to care for its owner.

When the ambulance(s) arrived, the Director noted that the smart door would remain locked due to the power cut. The door was broken down and the Paramedic, played by one of the workshop participants, entered the kitchen. They asked for all available medical information from the Smart Pet, who directed them to the Personal AI Assistant. The AI was in the process of responding to the door intrusion and was calling for the police. The Police (played by two workshop participants) used their electric vehicle to reinstate power to the house and the Paramedic again queried the devices for medical history. It turned out that the Care Receiver had a pineapple allergy, and the Director called an end to the scene. The actors and spectators then switched their roles and acted out a new scenario. The reflection round following the role-play was structured as a round table discussion. The facilitators used the value-oriented Keyword depicted on cards to jump start what quickly became a lively reflective discussion.

Participants’ background in design and their familiarity with technology and its imaginaries, helped introduce both complexity to the role-play and diverse perspectives to the discussions. Participants developed a wide range of nonhuman characters, presenting different intentions, capabilities, and behaviors. These sparked discussions around responsibilities and human (mis)conceptions of what a given technology can do.

### 5.3 Insights gained from Sensing Care Workshops

The experience from the variations of the Sensing Care workshop demonstrated how our approach could provide a space for designers, developers, researchers, and citizen participants to explore the design terrain of future sensing technologies, the associated entanglements and the role these technologies may play interdependent forms of care. Below we reflect on the insights from the workshops along the four primary concerns expressed by the industry partners in initial interviews: *multiple voices and actors*, *interdependence*, *situatedness*, and *performativity*.

**5.3.1 Multiplicity of voices: Who has which capacities to act?** Multiplicity of voices came into focus strongly when the different actors within a situation negotiated their capabilities to act, both functionally as well as appropriately. The role-play allowed participants to reflect upon the "social roles" of sensors as actors within the contexts they played out, challenging who gets to act and when. Questioning the extent of agency, power and control sensors bring into their responsive roles brought up the question of *capacity to act*. Participants reflected upon how far capacities of sensors in these situations should reach – was their function only to collect data, to inform about certain aspects of the situation (such as health stats) or should they also be expected to act upon it? Participants acting out sensors often chose to react when a disruption was introduced, weighing the different priorities they could adopt. This created tension, conflict, and possibility of failure, where choices and judgments had to be made about the appropriateness of the intervention. Consider the quote from a discussion following the role-play scenario described above, where a wearable device proves fairly unhelpful.

W3 P4: *"I think the conflict between the wearable and the caregiver and how the wearable wasn't willing to do certain things that the caregiver wanted to happen and that locking down what courses of action the caregiver had was quite an interesting element as well."*

W3 P7: *"But yes, who's in control of that? Is the wearable device yours? Or is the caregiver in control of what should happen or who has the power—"*

Importantly, participants enacting sensors often realized that there was no neutral action they could take, and that each action carried a normative judgment. A crowd sensor arranged by the city alarming the police within their functional protocol might result in a very different outcome than a concerned and informed family member alarming the police explicitly for help. Such actions also carry different connotations for privacy, where one participant might prefer the sensor to act, while another might prefer no intervention from technology and feel better cared for when people are in charge.

**5.3.2 Situatedness: What are the parameters of action?** The situatedness of the exercises brought out the complexities around the normative importance of the capability to act. Realizing what might be the "wrong" or the "right" thing to do, relies on whose priorities and perspectives are favored in the situation. Participants embodying sensors who witness a disruption had to decide whether and how to intervene. Doing the "right thing" for the sensors was a

normative act made possible by their programming. In response, participants reflected on which contextual factors were important to decide 'who' or 'what' should have the responsibility to get involved in which kind of situations, and with whose interests in mind. For example, a participant in one of the speculative enactment versions of the workshop noted:

W2 P2 *"I think it's interesting that the crowd sensor took into account your condition and called the doctor, but at the same time, there was a visible conflict going on and what if you had called the police and how would that change that situation?"*

Moving further into the entanglements of relations between people and technology, participants confronted the social inadequacy of sensors to appropriately act and respond. Following questions of roles – who should act when – participants reflected upon appropriate *parameters of action* for technologies, the "acting how?" given the situation. Speculations emphasized the disruptive impact some interactions had on the overall social and physical context. Consequently, participants who played sensors struggled with the tensions they felt from the discrepancy between what would have been perceived as socially appropriate and what they imagined was within their technical capabilities. Most of the time people inhabiting technology roles attempted to be helpful, but often failed by causing too much information exposure or limited necessary action by being obtuse.

Of course, the ability to read context appropriately is (currently) a human capacity and participants struggled to imagine sensors acting appropriately, as care situations can be unpredictable and complex. These situations require nuance to navigate correctly, especially where social norms can be challenged or broken. Within suddenly unpredictable situations, the capacity of sensor technologies to adapt appropriately to the required *parameters of action* became an important point of tension that strongly influenced what participants considered trustworthy and reliable.

**5.3.3 Interdependencies: Care-full entanglements.** The notion of interdependencies puts the focus on the relational nature of living with technology. Within the workshops, the notion of trust surfaced as an important point of contention throughout the role-play and in post-hoc reflection discussions. Trust was discussed as an emergent quality of situated interdependencies and negotiated tensions. Rather than an objective or outcome of a scenario, trust emerged and disappeared, depending on who acted when, how, and in which context. As technologies intervened in or became part of different social configurations, trust became a key component. For example, participants considered trust when discussing the scenario where the pizza dinner went wrong:

W3 P3: *"That's also something that I think is comforting in a way that they [the paramedics] all know what to do, but if needed, they can also break that rule."*

W3 P4: *"Just like there's trust that they [paramedics] know what's appropriate, what's appropriate to follow what is not appropriate anymore in this context."*

W3 P2: *"On that note, even if these smart sensors did have the emergency protocol in, would you trust them similarly, as you would trust someone with that human discretion in that situation?"*

W3 P1: “No”.

Trust is a relational component of interaction, emerging from the interdependencies within context, rather than an inherent characteristic of a person such as a caregiver, or a technology such as a specific sensor or sensor network. Consistent trust is an unattainable quality to design for, since technologies themselves are part of shifting and changing relationship dynamics, which often include unexpected situations and contexts where actors grapple with shifting motivations, roles, and responsibilities. Trust emerged not as a challenge to be solved by functionality or sensor design, but as a consideration for how people want to receive and distribute care. Our method provided an exploratory space in which the participating designers could experience the fluidity of trust and participating older adults could express how different manifestations of trust shaped their experience of care and support.

*5.3.4 Performativity: Acting out vulnerabilities in automated systems.* The focus on care allowed us to move beyond the idea of using sensors to provide situational assistance towards the invisible network effects that come into being through the connections of various actors. The touchpoints between care receivers, technology, and care providers surfaced in concrete situations of vulnerability. Tensions of power, authority, and control surfaced when the enactments became more tangible and relatable. Reflecting on the enactment, participants mentioned the stress they experienced in needing to decide in advance which priorities they ought to honour and then see how the enactment evolved. Performing these situations of vulnerability gave the participants a way to enter situations and experience the intangible and delicate undertones in care interactions.

W2 P3: “You’re not getting heard. Your watch is getting heard.”

W2 P6: “Yes, that’s right, and my doctor is getting through to my watch, but not me.”

People performing as technical actors highlighted the power relations more clearly, as the participants experienced the stress of their responsibility, due to the consequences of their interventions. While a sensor as a technology cannot take on accountability, a person can. For the care receivers, having a person to point to, to assign accountability for their experience highlighted the power relations more clearly.

## 5.4 Reactions from industry partners

As well as participating in the pilot workshops, we presented the final workshop process and findings to industry partners through a series of discussions. The two organizations took different things away from the experience.

AMS found that the outcomes of this work resonated with their effort to enable citizens to question the decisions of automated systems or to give people the power to challenge the design of sensors. AMS designers and technologies noted that the workshop method extended and complemented the current know-how and design process enacted in the institution. The deck of cards and the role-play mechanics could be integrated into the current design processes to provide additional insights that arise specifically from humans playing the role of sensors both for engaging external

stakeholders as well as for getting different internal team members to challenge their own assumptions.

For ACRC, the learnings reflected those of AMS but were located in an organization that was much newer. At the time of the project, the ACRC was still establishing how design methods and processes would be embedded within the team’s work. Some ACRC members come from a design perspective and use a range of co-design approaches, exploring the social qualities of care and the role of technologies in community and family care relationships. However, for many ACRC stakeholders this was their first exposure to a design process, especially one that engaged in role-play and speculation. The ACRC team engaged in the workshops reported the value of being immersed in an experience that allowed them to explore and express the “unintended consequences” of the technologies they are involved in developing. In particular, they saw how the introduction of interventions intending to promote specific health, wellbeing, and social outcomes could unintentionally amplify potential issues of power, authority, and even differential treatment through unexpected new behaviors and practices. The workshops also engaged the ACRC team in reviewing the different systems they are developing as an ecosystem of technologies that, when deployed in the world, can act together in “entangled” ways. Our work prompted ACRC to reconsider the siloed nature of much design and development work across projects, creating conditions where future service concepts can draw together the various sensors and other digital care systems that are under development into more broadly defined service offerings.

## 6 DISCUSSION

Our project sought to address industry partner concerns about the challenges posed by the technologies they were developing, by reimagining ‘living with’ sensor networks from a place of care. The workshop set up and materials allowed participants to roleplay future situations without much preparation. This was of paramount importance for our industry partners. A key concern has been to enable the enactments to take place in organizational settings, yet be able to capture the situatedness in living with sensor networks everyday life through storytelling and play. Furthermore, flexibility in the workshop’s infrastructure allowed its tailoring for different types of content, kinds of participants, and group sizes. For example, different topics, values, and technologies may be added based on the aim and scope, levels of criticality, and other factors that roleplay can accommodate. The different versions of the workshop are suitable for different audiences, both designers and non-designers. The use of professional actors could offload some of the required creativity to ‘play’ technologies, allowing non-designers to focus on their own lived experiences, while assigning a ‘director’ and ‘audience’ in the workshop helped to accommodate larger groups. Thus, the method offers ways to explore the complexity of socio-technical sensor-network systems in ways that can flexibly accommodate diverse audience needs and capacities. As the scenarios played out by the participants in our workshop highlighted, in moments of disruption, providing care means more than just being able to measure vitals or record the situation - it requires nuanced reaction that takes numerous variables into account and makes space for

the negotiation of value tensions to be a productive part of engaging with one another care-fully, showing due consideration. Care provision is not a one-sided activity - the sensors require care and effort from the people they attempt to serve, and their presence and functionality can affect existing social relationships around provisions of care in ways that are in fact counter-productive. In the end, who trusts technology remains an important question - do we trust it to inform us completely, to act appropriately, and to care for us? Our method informs such questions in three ways:

### 6.1 Designing for unfolding value tensions

The improvisational role-playing nature of the method allows participants to bring value tensions to the fore. By bringing together diverse stakeholders and participants in workshops, outside of their everyday settings, we were able to show how the different positions, priorities and values interact with each other and come into tension. Crucially, the Sensing Care workshops supported this, through its role-play methods to act out and, in some ways, experience these value tensions firsthand by immersing participants in possible situations and interactions of the future. Furthermore, diverging from most uses of speculative methods, which tend to focus on working with users and stakeholders external to a design team, our work demonstrates the importance of structured speculation with the design and development team. Solely conducting workshops with stakeholders and envisioned users is not enough for understanding entangled systems -it is important to have designers go through the same experience as well, and to scaffold reflection on value tensions post-roleplay, recognizing their role in the move toward 'living with' sensor systems.

When value tensions surfaced, at times they could be worked through, and even resolved, during the role-play. Our approach engages with the fact that ethics and human values are not something that can be 'solved' through design methods. Instead, they are reworkable, time-dependent, complex, and require time and space to be explored. Trust, for example, is a complex and multifaceted concept that will always remain difficult to operationalize in concrete and logical terms, as some of its manifestations constitute what can only be described as a leap of faith [42]. Our workshop outcomes demonstrated that designing sensor network-based systems needs to go beyond compliance with privacy policies such as the GDPR, and seriously consider trust and other values as shifting components shaped by living, by making space for negotiation and contestation. Both these things require time, and thus might inherently clash with the firmly established direction towards optimization and efficiency. While there are many methods for surfacing value tensions, our approach helped to not only surface value tensions through situated role-playing, but also allowed participants to engage with and work through them in a discursive, performative manner. The reflective component at the end of the workshop allows participants to discuss and analyze these challenges and use the value tensions as a resource for design. In this way values are not defined as just abstract heuristics but instead situated as part of the deliberations of how to design for a specific domain.

### 6.2 Designing for entanglements of care

Our approach departs from the design traditions of industry partners by positioning sensors as actors within a complex network of people and things and not as siloed solutions to potential care dilemmas. The roles of the sensors themselves became an important part of the unfolding of care situations. By entering acted out scenes, the sensors inherently changed the fabric of the situations. In this way, our approach shifts the imaginings of technology, from solutionizing to entanglements. After all, if technologies cannot be imagined differently, they cannot be built differently. We developed our speculative workshop method to address the importance of offering iterative speculative interventions. These created conditions to push designers and potential users of technologies to find creative ways of questioning what technologies are today and what they could be tomorrow, by exploring relational and caring imaginaries of living with technologies. New technologies will always require new design methods, but they also require us to think differently. One might argue that sensor technologies are not new technologies by any means, but as they meet complex, entangled socio-material contexts, they generate ever greater controversy.

Our method enables an exploration for how to design when values such as trust and privacy are fluid, in a situated and performative manner. There are no answers to how we might design our way out of the value tensions surfaced and explored by the participants of our workshops. Instead, these are negotiations that need to happen repeatedly and require opportunities for challenge and contestation in use, not just during the design phase, as that is not where answers can be found. This means that designers themselves must change in shifting their fundamental approaches to technology design away from a user-centered optimization towards facilitation and making space for care.

### 6.3 Designing for the speculative but consequential future everyday

A key consideration for speculative activities that involve workshoping through future scenarios is ensuring plausibility of the situation's participants experience. In Elsdén et al.'s work [17], they positioned their enactments as engagements with mundane situations which people may live through in the present but adjusted to account for the speculated data driven services being explored. The consequentiality of the enactments comes, in part, from the grounding in the everyday mundane situations of now. However, this poses a challenge, as what is every day and mundane now will not necessarily be the case in the future, when these speculated technologies are deployed. Yet at the same time, the consequences of technologies that are in development need to be explored in the present. Our approach enabled participants to experience speculation by placing them in situations where they had to make judgements and decisions at a relatively fast pace, recognizing that what they said and did in the role-play influenced the direction of the story and would have consequences for the other characters being played out. Stepping in and immersing themselves in the future everyday situation, and then stepping back and reflecting with other participants, produced insights that helped designers shift and expand their view, as well as provided a new basis for ideating solutions that are sensitive to the challenges of entangled sensor networks.

There are recurring questions about the value of design approaches that are underpinned by participant engagement via workshops [48] as opposed to engagements in everyday settings or through real-world interventions. Exploration of engagement in more naturalistic settings, however, can be hindered by the fact that these technologies are yet to be designed as well as potential costs to mimic future scenarios through prototyping. Our method helps design teams that are looking for ways to understand what might constitute responsible and ethical systems in the near future, through flexible and affordable means. Our participants reported enjoying the workshop activities as well as, in the case of designers, finding them valuable for their own work. We configured the workshop experiences to be of direct relevance to, and having consequences for, the current work of our industry partners, who appreciated the resulting outcomes.

## 7 CONCLUSION

In this paper we describe a speculative workshop method, Sensing Care, which operationalizes roleplay techniques to support participants to experience the complexities of living with sensor networks with a focus on care. Our workshop engaged speculation and improvisation through role play, enabling a multiplicity of voices with attention to situatedness and interdependence surfaced through performativity, to make socio-technical entanglements experiential and open for scrutiny. Taking departure from current work on speculative enactments, we opened up roleplay to multiple participants to help surface value tensions coming from the interdependencies between human and nonhuman actors, through improvising their roles and agencies within specific situations triggered by disruptive events.

Through this approach the workshop made the intricate relational qualities of sensor networks experiential as dynamic interactions within sociotechnical systems and surfaces. The set-up of the roleplay allowed participants and stakeholders to explore future situations of care provision through sensor networks as something socially and technically entangled. The proposed method is suitable for use with external stakeholders and internal teams within organizations. It aims to dismantle potential silos between designers, developers, user researchers, data scientists, and others who collaborate on various aspects of the same technology. As the technological landscape evolves, becoming more integrated into our social realities, methods that identify conflicts in "living with" technology are crucial. We anticipate that this method will aid in gaining a better understanding of how to design sensor technologies that interact and intersect across different contexts to enhance the quality of living with them.

## ACKNOWLEDGMENTS

We thank the researchers, lecturers, and doctoral students at University of Edinburgh who helped us with their insights. We also thank the Patient and Public Involvement Group at ACRC for their time and feedback on our first iterations of this method. We thank the designers, researchers and developers at AMS for their time and feedback for the narrative development.

This work is part of the DCODE project. The project has received funding from the European Union's Horizon 2020 research and

innovation programme under the Marie Skłodowska-Curie grant agreement No 955990.

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