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Crafting the future of the artificial womb - speculative design as a tool for public engagement with emerging technologies

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ABSTRACT

This study aimed to characterise the potential of speculative design in public engagement with emerging technologies. Current initiatives in public engagement have important drawbacks, such as the focus on quantifiable impacts, abstract reasoning and difficulties in imagining potential futures. Speculative design is considered a promising tool for public engagement because of its ability to open up dialogues about the societal implications of emerging technologies. Realising its potential depends on a thorough understanding of the reflective practices induced by speculative design. In this study we identified enabling factors for reflective practices to unfold and 3 ways of questioning human-technology relations, namely through scenarios, stereotypes and lived experiences. Our findings show that speculative design encourages imagining futures and facilitates reflection on qualitative impacts in various forms of knowledge by providing thought-provoking prospects. The medium has shortcomings, however. For participants to take on the role of creative moral agents the design needs to tread the fine line between activating them through ambiguity and informing them. Comparing our findings with pragmatist ethics, we show how speculative design can put into practice the four most prominent features of pragmatist democratic ethical deliberation.

1. Introduction

Emerging reproductive technologies have the potential to radically alter society. They give shape to our relationships, our standards, values, rights, duties, expectations and desires (Swierstra & te Molder, 2012). The artificial womb that is currently being developed is intended to increase survival rates for premature babies, but may also affect our sexuality, parental responsibilities and our prospective families (Pau & Hall, 2021).

The complex and profound impacts of emerging reproductive technologies call for public involvement in the development and social embedding of these technologies (Fiorino, 1990; Stilgoe, Lock, & Wilsdon, 2014; Willems, Heltzel, Nabuurs, Broerse, & Kupper, 2023). However, it is complicated to establish an effective public dialogue on the impacts of new technologies, especially when this pertains to what it means to be human, ideas about the good life or what a future society will look like. First, these 'soft impacts', as Swierstra and te Molder (2012) describes them, on the cultural, moral and political impacts of new science and technology on society are easily overlooked in public dialogue initiatives. There is a risk such initiatives will focus on quantifiable impacts, such as health outcomes, safety measures and economic benefits rather than discussing qualitative 'soft' effects (Krabbenborg & Mulder, 2015, p.469; Swierstra, 2015). Second, current initiatives are criticised for focusing on the exchange of rational arguments, rendering it difficult to

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include other types of knowledge, such as affective reasoning and embodied knowledge (Roeser & Pesch, 2016; Davies, 2014; Cuhls & Daheim, 2017). Roeser et al. (2018) argue that this is problematic, because emotions, such as compassion and feelings of responsibility and justice, are important sources for understanding our moral judgement of emerging technologies. Third, both the public and professionals find it difficult to imagine unknown futures, and thus miss the opportunity to explore important values, meanings and experiences (Felt, 2015). Fourth, it is a challenge to overcome one's own (moral) inclinations and empathise with the perspective of others (Roeser et al., 2018), while narrow personal perspectives may hinder open public dialogue on emerging technologies. Finally, the formats of public engagement initiatives often treat public opinion as a static entity that can be harvested. However, public opinion is constructed in an active process of moral deliberation that is shaped in continuous interaction with other deliberators (Fesmire, 2003).

There are examples of projects (both initiated by governments and by intermediaries such as Science and Technology Studies scholars and science museums) that attempt to create more reflexive public engagement initiatives aiming to overcome the aforementioned barriers. For example, Dortmans (2016) zoomed in on the potential role of the facilitator in face-to-face upstream public dialogue with citizens and scientists on emerging technologies. Boenink, Swierstra, & Stemerding (2010) propose the use of techno-moral scenarios to reflect on moral standards and thereby inform and enhance public dialogue. Finally, to foster additional forms of knowledge beyond reasoned argument Davies (2014) encourages the use of more diverse forms of interaction such as storytelling, pictures, songs and poetic imagery. According to the author "Good deliberation should incorporate space for emotional, creative – even disorderly – modes of communication."

To understand the importance of the drawbacks of, and potential solutions and recommendations for public dialogue initiatives the pragmatist perspective on democratic ethical deliberations provides useful insights. In the pragmatist perspective ethical deliberation is described as an open, experimental and creative inquiry through which society develops solutions to new and unexpected situations that arise with the introduction of emerging technologies (Cuhls & Daheim, 2017). Deliberators engage in a 'dramatic rehearsal': they try out different courses of action to predict potential outcomes (Fiorino, 1990). There is a profound theoretical understanding of these issues (Cuhls & Daheim, 2017; Fiorino, 1990) and in a number of articles authors reflect from a pragmatist perspective on the practical aspects of democratic public deliberation initiatives (Dortmans, 2016; Dunne & Raby, 2013; Kupper, 2017; Macnaghten, Davies, & Kearnes, 2010). However, such aspects and potential tools for facilitating such deliberation remain underexplored.

Speculative design is considered a promising tool for public dialogue as it may be able to put dramatic rehearsal into practice by taking into account some of the best practices aforementioned; such as the use of techno moral scenarios and emotional and creative modes of communication. The speculative design practice uses fictive design objects to explore future scenarios and open up debates about the social, cultural and ethical implications of emerging technologies (Felt, Fochler, Müller, & Strassnig, 2009; Heidingsfelder, Bitter, & Ullrich, 2019, 2019; Tsai, Wang, Lee, Liang, & Hsu, 2014; Wouters et al., 2019). Prominent speculative designers Felt et al. (2009) describe their practice as materialising critical thought to engage people in thinking about possible futures and using these to understand the present and discuss the kind of future they want. Their futuristic designs form a speculative philosophy of technology that sparks imagination about potential futures and the meaning of technology in a contextualised approach.

In order to understand and benefit from the potential of speculative design to open up democratic processes on emerging technologies by putting dramatic rehearsal into practice, it is necessary to have a thorough understanding of the reflective practices that the medium stimulates (Davies, 2014). So far, most studies on speculative design focus on the perspectives of designers, politicians or the output of co-creative design processes (Angheloiu, Sheldrick, & Tennant, 2020; Kelliher & Byrne, 2015; Keulartz, Schermer, Korthals, & Swierstra, 2004; Pelzer & Versteeg, 2019). Only a limited number of studies have aimed to better understand the reflective processes of participants engaging with the speculative design (Roeser & Pesch, 2016; Grunwald, 2010).

In answering Roeser et al. (2018) call for 'new theories, frameworks and perspectives concerning the relationship between art and morality in the context of risky and controversial technologies', this study aims to identify the potential of speculative design to facilitate pragmatist dramatic rehearsal in public engagement with emerging technologies. The research was designed as a case study on a speculative design installation of an emerging reproductive technology, the artificial womb. The imaginary prototype created by the speculative designers' collective, Next Nature Network, aimed to open up a public dialogue about the cultural, moral and political impacts of the externalisation and medicalisation of pregnancy.

2. Theoretical background

2.1. Pragmatist ethics

Pragmatist ethics is considered a useful perspective to make sense of the soft impacts of emerging science and technology (Keulartz et al., 2004; Kupper, 2017). Pragmatist ethics is anti-dualistic and emphasizes that scientific facts and technological artefacts are not in contrast but rather co-evolve with moral norms and cultural values (Krabbenborg, 2016). Additionally, pragmatist anti-foundationalism argues that to develop adequate responses to an ever-changing world one cannot rely on pre-established ethical frameworks (Kupper, 2017; Keulartz et al., 2004). Rather, the process of moral inquiry is open, experimental and creative, and relies on the human capacity to reconstruct habits and routines in resolving our problems (Cuhls & Daheim, 2017). Authors in the field of science and technology studies and public engagement have used the work of pragmatist Dewey to reflect upon public engagement events on emerging technologies (Shelley-Egan, 2011; Swierstra, Stemerding, & Boenink, 2009). His conceptualisations of the public, reflective inquiry, moral imagination, and dramatic rehearsal help to understand the dynamics in these settings.

For Dewey there is no pre-existing public to be consulted in the event of emerging technologies. Instead, a public arises when these emerging technologies affect others in ways that existing institutions and arrangements cannot handle the consequences of adequately

and indeterminacy is experienced (Kupper, 2017). Building on the work of Dewey, Nordmann (2007) emphasizes that a public is not organised on the foundation of its geographical, social or institutional identity but is bound by an issue. For Dewey ‘A public always emerges in relation to concerns about an indeterminate situation: a situation in which it is not clear how to act, what to value, and what is at stake’ (Kupper, 2017). A distinction is made between a passive and active public (Caspary, 1991). Those who experience the effects of the issue form a passive protopublic and become an active public when starting a reflective inquiry. In Dewey’s work the reflective inquiry is a deliberative act amongst those who are affected by the issue and experience the indeterminate situation. They address questions about who is involved, how to act and what to value by inquiry, their moral imagination and dramatic rehearsal (Keulartz et al., 2004). Dewey emphasized that the inquiry is a collaborative act. Answers to the aforementioned questions are answered through sharing experiences and questioning each other. The reflective inquiry is a space in which participants articulate what is happening and construct new or adapted frameworks to make sense of the indeterminacy.

There are four distinct stages in the reflective inquiry (Kupper, 2017). After the initial experience of an indeterminate situation, firstly the indeterminacy is transformed into a problematic situation by the identification and articulation of the problems at stake. These problems concern the negative consequences of an act in daily lives and routines. In response, the public thereafter formulates potential solutions to the articulated problems. In this phase participants hypothesize the possible consequences of choosing a line of action. Thirdly, participants reflect on the consequences of choosing a line of action for all of those involved. Finally, participants test (in real life) the preferred solution through experimental testing. The preferred solution should address as many problems as identified in the first phase as possible (Kupper, 2017).

Throughout the stages of reflective inquiry, participants make use of their moral imagination and do so in a reflective inquiry that Dewey characterises as a dramatic rehearsal (Fiorino, 1990). Such moral imagination is described as empathetic projection by which moral agents consider others’ aspirations, interests and worries as if they were our own – not by projecting their own values and intentions onto others but acknowledging individual differences and adopting the perspective of the other (Fiorino, 1990). Using moral imagination enables deliberators to creatively explore future possibilities as opposed to relying on conventions and habits, which hinder dynamic adjustment and may result in uniformity. Through moral imagination ethical deliberation becomes a creative-intelligent inquiry through which society develops solutions to new and unexpected situations that arise in the introduction of emerging technologies (Cuhls & Daheim, 2017). Or, put differently, moral imagination is ‘the capacity to concretely perceive what is before us in light of what could be’ (Fiorino, 1990, p. 65).

Deliberators use their moral imagination in a course of ‘dramatic rehearsal’: they try out a plurality of possible futures and the ways towards their realisation to imagine potential outcomes (Fiorino, 1990). Firstly, deliberation is considered *dramatic*, as deliberators explore possible meanings, conflicts and behaviours in an unfolding narrative or plot. Secondly, deliberation is *social* as it requires anticipating the responses of other people and one’s own. Thirdly, dramatic rehearsal requires emotional sensitivity to anticipate and evaluate the responses of others. As we carve out potential future scenarios through our imagination, we use emotional reactions, desires, and aversions to evaluate their moral acceptability. Fourthly, in the process of imagining different courses of action deliberators reconceptualise concepts that we use to identify, order and interpret situations. Finally, dramatic rehearsals are of an open-ended and indeterminate character (Fiorino, 1990; Keulartz et al., 2004).

2.2. Speculative design

This study aims to investigate whether speculative design can facilitate pragmatist reflective inquiry; activating publics to perform a dramatic rehearsal and use their moral imagination to make sense of the soft impacts of emerging science and technology. The speculative design practice, which borrows from the fields of futurology, political theory, philosophy of technology and literary fiction, is seen as an exploration of what could be by imagining potential futures (Felt et al., 2009; Grunwald, 2010). Rather than aiming to forecast or predict the future, speculative designers aim to pose ‘what-if’ questions with the intent of opening up a conversation about

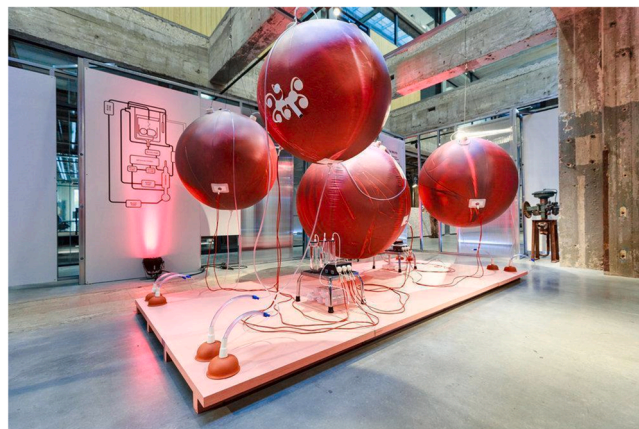


Fig. 1. Speculative prototype of artificial womb technology at Dutch Design Week '18.

the kind of future people want. Participants who engage with speculative designs are encouraged to question, critique, and challenge (technological) developments and the ways in which they give shape to society. Spectators use their imagination through artistic tools such as cautionary tales, prototyping, what-if questions, thought experiments, world-building, counterfactuals, reductio ad absurdum experiments, satire and critique. Rijkens-Klomp, Baerten, and Rossi (2017) coined the term 'imaginative logics' to characterise the typology of speculative designs. The term refers to the set of principles that constitute the speculative designs, by means of which an abstract phenomenon is presented to the audience (doable, juxtaposing, defamiliarizing, guerilla and procedural imaginative logics). Speculative designs do not suggest how things should be, which is considered too didactic and even moralistic, but rather aid imaginative thought as a means to discuss the present and the future we want (Felt et al., 2009). Using speculative design to explore and deliberate on technological futures aligns with the aim of science and technology studies to facilitate public engagement as a means to democratise the development of science and technology (Heidingsfelder et al., 2019; Heidingsfelder et al., 2019; Tsai et al., 2014; Wouters et al., 2019).

3. Methodology

In order to explore the reflective practices induced by speculative design, a case study was conducted on a speculative design installation of an artificial womb (Fig. 1). The design was created by the speculative designers' collective, Next Nature Network (NNN), in collaboration with researchers at the Maxima Medical Centre, Veldhoven (MMC). NNN creates speculative design exhibitions on various emerging technologies, such as gene editing, robotisation and in vitro meat, to stimulate public dialogue on the impacts of these innovations on society. They collaborated with MMC researchers currently developing a working prototype of the artificial womb for premature babies (Davis, 2019a). The installation was exhibited at the 'Embassy of Health' at the Dutch Design Week Eindhoven in the Netherlands in 2018.

The design was composed of five balloon-like spheres of between 80 and 120 cm in diameter. The balloons were made of plastic on which was printed a pattern in different shades of red. They were hung up in a spatial arrangement above a pink base plate of 3×2 m. A set of tubes connected the spheres with glass cylinders, a black rectangular device with the appearance of a measuring instrument and a suction cup. A panel with a printed blueprint of an incubator patent was placed alongside the installation.

3.1. Data collection

The Dutch Design Week Eindhoven in the Netherlands is organised for the general public and attracts a diversity of visitors in regards to age, professional backgrounds and interests. We selected participants by observing which visitors were looking at the installation and were discussing what they saw amongst each other. Also, we selected individual participants who had been observing the installation for a few minutes. We did not engage visitors who swiftly passed by the installation but did not show signs of observation or reflection about what they saw. Researchers were mostly engaged in conversations with > 2 visitors, often visiting the installation together. Sometimes researchers had a conversation with individual visitors. Occasionally, researchers engaged in a conversation with visitors and other unknown visitors joined the conversation.

No pre-existing ideas on speculative design's working mechanisms had been previously described in literature. To answer our exploratory question on the potential of speculative design in deliberative processes we gathered qualitative data in the form of semi-structured interviews for visitors to reflect freely and openly. Five researchers engaged participants in conversations using a format of three questions: What do you see? What in the installation makes you think that? Do you have any thoughts about what you see? The semi-structured interview format provided room for additional probing questions about the installation and their thoughts about the future of the artificial womb. Researchers audio recorded summaries directly after the conversations. The summaries included a description of the participant(s) (e.g. number of participants, sex, estimated age), a general impression of the conversation (e.g. duration, tone, topics discussed, most important arguments used) and observations that stood out (e.g. shared stories and memories). By immediately recording the summaries after the conversations we minimised recall bias (Rutakumwa et al., 2020). The conversations were not directly audio-recorded because of the acoustic conditions of the hall where the artificial wombs were exhibited. The Dutch Design Week is a crowded festival with over 40.000 visitors per day. The industrial hall itself has high ceilings and concrete walls making audio-recording with sufficient quality particularly challenging. The recorded summaries were then transcribed for qualitative analysis.

3.2. Analysis

The work of Bowen (2006) on grounded theory and sensitizing concepts was used to guide the analysis of transcripts and theory-producing process. A set of sensitising concepts was identified in the work of leading speculative designers Felt et al. (2009) and Auger (2013) to guide the initial analysis. These concepts included examples of different artistic tools (e.g. prototyping, alternative realities), style characteristics (e.g. playful, provocative), functionalities of the design (e.g. making tangible, world-building) and intended experiences (e.g. emerging oneself, desirable discomfort). The sensitizing concepts were used to lay bare the patterns between experiences of the speculative design installation and the process of pragmatist reflective inquiry as dramatic rehearsal. A process of open, axial and selective coding was performed using MaxQDA software. The first two authors analysed the data independently and codes were discussed. Subsequently the analyses were deliberated with the third and fourth author in order to sharpen the patterns found. This cycle was repeated several times.

4. Results

We had 28 conversations with 44 participants. Participants were between 18 and 70 years of age, of whom 27 were women. In the data we found that in the reflective practices sparked by speculative design visitors questioned established human–technology relations. In the results section we first address (1) the enabling factors for such reflective practices to unfold, and (2) three different ways in which this questioning was conducted: (a) through scenarios, (b) stereotypes and familiar ways of doing and (c) lived experiences.

4.1. Enabling factors for reflective practices to unfold

Firstly, the interaction with the artificial womb installation made participants question assumptions and current ways of thinking about human–technology relations. The following paragraphs describe two characteristics of this process.

4.1.1. Engaging with what-if questions

The reflection on the potential impacts of artificial womb technology on society required participants to imagine fictitious scenarios in which the artificial womb has been developed and is being used. The majority of participants engaging with the installation suspended their disbelief and engaged in the thought experiment of imagining how and by whom artificial womb technology would be used.

Our findings show multiple stages in the process of participants engaging in what-if scenarios. Participants' suspension of disbelief started with imagining the design on display to be an artificial womb and imagining the technology had been adopted by a future society. Initial evaluation of the installation's physical appearance often led participants to envisage a potential physical setting in which the design could be used, and subsequently to imagine its practical implications. Thinking about these practical implications led to an ethical and meta-ethical reflection on the embedding of the technology. Participants used what-if-questions to explore ideas of safety, sense of security, and parental expectations.

The interaction with the installation was a gateway for the reflection on cultural, moral and political impacts of the artificial womb. The interplay between the installation's physical characteristics and the what-if questions that were raised steered reflection. Physical characteristics both fed participants' imagination and were scrutinised for their alignment with participants' vision of a speculative future. The following fragment is illustrative of the way in which participants tried to connect the installation's physical appearance with an understanding of technical functionalities of the speculative prototype and associated moral questions:

Fragment 1

They understood the installation was about the ability to create wombs outside the body. In particular, they searched the prototype for ways in which nutrients would be administered. They thought it would be useful to be able to administer these in the external uterus much faster than in existing incubators. Medical staff would have easy access and could make more accurate measurements. They envisaged that if people had an artificial womb at home they would not have to be hospitalised if the technology could eventually take over a much larger part of the pregnancy. [...] They raised questions about whether people would be allowed to use this technology when they could get pregnant in the natural way. They speculated that people might want to use this technology just because being pregnant would be inconvenient for them. They asked out loud: Would that be okay? Or would the use of this technology only be allowed if there were no available options for a natural pregnancy? [...] For them the most important concern was that everyone wanting to have children should be able to use this technology.

This fragment shows how participants first reflect on the visual characteristics and functional design of the speculative prototype, after which reflection on healthcare practices follows and then the reflection becomes more profound by discussing ethical questions and underlying moral values. Thus, what-if questions steer the kind of visual cues participants look for in the installation and then these visual cues encourage further imagining of future scenarios. The what-if scenario of creating wombs outside the body, visual cues that could reveal how the baby would be nourished, and speculative scenarios on the effect of the technology on healthcare practices together form an interplay informing and shaping each other. This interplay ultimately led participants to ask the moral question of whether there is a right to parenthood.

A number of participants found it difficult to use their imagination and looked for a reality to hold on to by continuously asking for scientific explanations and objective facts. They did not seem to feel empowered or trust their lay expertise sufficiently to give shape to potential futures but rather left that responsibility to the scientific community. Their reflection typically focused on the health benefits for premature babies. For a few participants, the materialisation of the idea (the installation) became the subject of reflection rather than the scenarios it symbolised:

Fragment 2

The installation was not satisfying for participant 1 because she was mainly interested in the working mechanisms of the technology after reading a newspaper article. Now she just saw plastic things here. [...] Participant 2 said: 'It is a visualisation of what the technology might look like'. Participant 1 replied: 'Well I would like to see it, if those spheres are a genuine proposal, where would those embryos be?' [...] Participant 1 continued: 'I don't understand because I don't see a tube from the spheres to the baby'. Participant 2 replied: 'Well, it doesn't matter how it works technically, this [installation] is just to make you think about it'. Participant 1 replied: 'This is all very unsatisfying for me'.

From this fragment it becomes clear that the distinction between the real and the speculative played a prominent part in the

reflection of some participants. Participant 1 in this fragment expected to see a working prototype. Viewing it, she seemed disappointed and irritated that her expectation was not met, preventing her from engaging in the thought experiment. She was sceptical rather than critical of the installation.

Conversely, a small number of visitors believed the installation to be a functional rather than a speculative prototype. They 'believed' rather than 'suspended their disbelief' by considering the speculative prototype a finished design ready for implementation. Without the awareness of the speculative character of the installation participants did not actively give shape to and reflect upon the technology's design, forms of use and the consequences for society.

4.1.2. Ambiguity

The ambiguity of the installation, understood as the object potentially being explained in different ways, required participants to come up with their own frames of the technology. The ambiguous installation thus functioned as a rough sketch and the ways in which participants framed the technology depended on who they were, what they focused on and what they found important. The following fragment illustrates how in one conversation multiple frames were generated, which in turn were reflected upon:

Fragment 3

Participant 6 said: 'You just said something very interesting, namely that the artificial womb will be used by career women'. Participant 7 envisaged a world in which children would develop in a designed environment in which everything could be regulated. Participant 6 thought it felt bizarre to think of the artificial womb as valuable for pursuing a career and said she fiercely objected to such use, but thought it was a beautiful solution for premature babies as an improvement on the current incubator.

This fragment shows the interrelation between participants, the frames they use and the moral evaluations that flow from them. While participant 7 framed the technology as lifestyle medicine by referring to the use by 'career women', participant 6 framed the technology as an incubator 2.0 by describing the innovation as a 'solution for premature babies'. Participant 6 morally approves the use of the technology for premature babies by describing it as 'a beautiful solution', while 'she fiercely objected' to the use of the technology by 'career women'. In her moral judgement participant 6 contrasted an economic or cultural motivation with the purpose to achieve health benefits. In the following fragment the installation's ambiguity led to a critical discussion about the design characteristics of the artificial womb.

Fragment 4

The participants did not really realise that the installation was about a uterus, because they'd imagine a uterus to be warm and cosy. The installation did not come across as warm and cosy to them. One participant said: 'This is just a balloon. The attached tubes do not feel warm and cosy. Also, it is very large.' [...] They wondered why it was designed this way. One participant grabbed the tubes and said: 'Why are these here? Is it an umbilical cord? How did the baby get in? I just don't understand why it was made this way.' [...] I asked them what an artificial womb should look like for them to consider it warm and cosy. They indicated that it should be much smaller. That it should be something you can hold close to you. So, you can lay that baby in the womb against your heart. So, it can feel your heart and hear your breath or the surroundings. The design should enable you to embrace it, so that you can make contact with the baby. Because they didn't have that feeling now, with the balloons hanging there.

Here the ambiguity of the installation made the participants sceptical and unwilling to engage in the thought experiment at first. However, their criticism encouraged the researcher to follow up on their concerns regarding the design and technicalities and was thus able to re-open the conversation. The researcher's intervention made participants engage in a conversation about social consequences by discussing topics such as human obsolescence, career women, and different applications of the technology.

4.2. Three ways of questioning established human-technology relations

4.2.1. Scenarios

Participants' ability to question assumptions about established human-technology relations described in the previous paragraphs formed a requirement for the second reflective practice that was identified. Raising what-if questions and the ambiguity of the installation necessitates filling in the blanks, which participants did by crafting scenarios.

Participants gave shape and became owner of a speculative future by framing the technology as 'a beautiful solution for premature babies', 'a tool for career women', or 'a solution for infertile or homosexual couples', a device promoting remote healthcare, and as a political instrument. The frame that participants proposed inevitably raised a new set of questions while excluding others. They started to think about how the frame affects them and a speculative society. What will society look like with the object in it? In answering this question participants developed a scenario. They assigned meaning to the frame in the form of a societal narrative (fragment 5).

Fragment 5

The three participants engaged in a conversation asking each other what they thought of the technology. One of the participants said she brought up the idea of the technology becoming a tool for career women. Then they started visualising that scenario together. What if you could position the artificial womb in the nursery and attach a webcam to it too. Every now and then the mother will drop by and wave: 'mummy is on her way to a meeting!'

The fragment shows how participants' frame of the technology as a tool for 'career', or professional, women plays out in a scenario of a mother dropping by at a nursery in between meetings. Fragment 6 and 7 provide another example of the way in which the framing of a technology and scenario co-emerge. A scenario in which dictators will control artificial wombs to create children for state purposes framed the artificial womb as a political tool.

Fragment 6

Participants mentioned other people may be able to control this technology. So, maybe children without parents would be born. There are already dictators selling organs, well the participant could imagine that happening here too.

Fragment 7

Imagine a complete pregnancy could take place outside the womb. What if you'd set up factories filled with artificial wombs that could create soldiers. That is a very extreme idea.

4.2.2. Stereotypes and relating to familiar ways of doing things

The previous fragments illustrate how participants used their imagination to create scenarios about the impacts of the new technology on the wider society. However, they also reveal that participants relied on using stereotypes in filling in the openness of the installation. The participants in conversation fragment 11 portrayed the image of a professional woman mostly concerned with her own career rather than bringing up a child. The participant of conversation in fragment 6 fills in the open-ended scenario by referring to the stereotype of a maliciously intentioned dictator. The participant in conversation in fragment 7 referred to the symbols of a factory and soldiers. Participants filled in the open-ended character of the installation by referring to stereotypes that symbolise their concerns about the use of the technology, such as egoism, political abuse, and human instrumentalisation.

In addition to referring to stereotypes, a majority of participants made sense of societal consequences by referring to current practices and familiar ways of doing things, such as incubators and natural pregnancy.

Fragment 8

At one point participant 1 pointed to the spheres and said she appreciated the fact that you could not see through them. She said she thought that made them look protective, just like a [natural] womb is for the child.

This fragment is illustrative for the role that references to current practices play. They were used to validate participants' moral evaluation. Note how in fragment 8 participant 1 appraised a design characteristic (opaqueness), explained her rationale (opaqueness supports her moral value of protectiveness) and subsequently validated her opinion by comparing the protective design to the natural womb. Thus, the visitor's moral evaluation of the artificial womb went hand in hand with her reflection on functions of the female body and the relation between a mother and unborn child. Current ways of doing things provided the participant a moral anchor in her evaluation of this speculative prototype. This sense-making mechanism of using current phenomena as a moral anchor was identified throughout the data, in both positive as well as negative moral evaluations of the prototype. For example, in the following fragment participant 3 had a negative opinion about the design of the prototype by referring to the design of current incubators:

Fragment 9

Participant 3 emphasised the sense of protectiveness promoted by current incubators. Apertures in a see-through material enable parents to touch their premature child. That would not be possible if we use this speculative prototype. [...] How would people respond to that? What would that mean for people?

Thus, the fragments illustrate how participants referred to current technology practices to substantiate their judgement of the speculative prototype. However, the opposite occurred too, participants reflected on the ways in which the artificial womb would give shape to our ways of doing things in judicial procedures and would affect our ways of thinking by questioning ontological notions, such as personhood, reproductive rights and justice (fragment 10).

Fragment 10

The participant articulated several questions that he thought accompanied the implementation of this technology. For example, when would I need to report a child to the municipality? If it's in this womb? Or do we then perceive the baby as unborn still? Would I need to take out insurance for the baby separately? Do I regard it as a real person yet?

Conclusively, the open-ended character of the installation made participants come up with scenarios about the artificial womb's role in a speculative society. In the process of imagining scenarios participants brought together images, impressions, roles, intentions and values that serve to explore the possible, the plausible and the preferable.

4.2.3. Lived experiences

The following paragraphs will elaborate on the third way in which the speculative design installation enabled participants to question human-technology relations, namely by welcoming reflection on participants' emotional and the personal experiences in ethical reflection.

The emotional. Participants drew on moral emotions in forming and communicating moral evaluations about the depicted technology. The majority of participants showed social emotions of empathy and compassion. For example, a view frequently expressed was that the artificial womb could be a lovely solution for infertile or same-sex couples wanting to have children. A number of participants expressed emotions of wonder:

Fragment 11

Participant 2 said he wished the spheres had been transparent. Then he could observe the process take place from up close. 'I am very curious how it works. I would really want to observe the development of the child completely. Yes, observing it all day.'

However, participants also expressed feelings of disgust:

Fragment 12

Participant 1: 'You just said something very interesting, namely that in the future the technology would be used by career women'. Participant 2 was convinced that that would happen and said it would be handy. Then participant 1 replied: 'Yes, "handy" is the right word'. But she did not like it [...] Participant 1 found it bizarre to claim this technology would be 'useful for a career'. But she thought it was a very beautiful solution for premature babies, as she pointed to the installation. So, when she understood it as an extension of the incubator, then she did not find it at all threatening. But when it was framed as 'handy for a career', then she fiercely objected to its use.

From this fragment it becomes clear how participants used the expression of moral emotions to communicate their moral evaluation of the technology. Participants expressed feelings of disgust by using words as 'bizarre' and 'did not like it' to morally reject the frame of the technology as a tool for professional women. Whilst she expressed feelings of empathy by describing the artificial womb as 'a beautiful solution for premature babies', thereby conveying her moral acceptance of such use of the technology.

The fragments illustrate participants forming and communicating their moral evaluations on the technology through moral emotions of empathy, sympathy, wonder and negative emotions of disgust and fear. Sentiments were directly evoked by physical characteristics of the installation (the spheres looking like a factory) or by the idea of the technology and its potential uses (help other couples or replacing humans).

The personal. As described in the previous section the open-ended character of the installation required participants to craft their own scenarios. As discussed, they referred to stereotypes and familiar practices and ways of doing things. Importantly, participants also relied on their personal experience with reproductive technology or having children to make sense of the installation. Their personal experience affected what they saw in the installation and what they reflected on. The experiences functioned as a searchlight focusing reflection on certain parts of the installation, so that participants evaluated the design by comparing it to their personal experience and predicting what the future of the artificial womb might hold.

Participants' professional experience also significantly shaped what participants saw in the installation and what they reflected on. The following fragment is from a conversation with a designer working at Philips developing medical technology:

Fragment 13

The participant would like to know in what kind of environment people see this technology being used. Also, how would you like this technology to be explained to you if you were a patient? How would you like a doctor to reassure you about this technology? 'Reassurance', he argued, 'is an important element of providing care'. An important task for care providers is explaining people what is happening. He'd like to ask people: 'What would you need to trust this technology?'

This fragment illustrates how the participant's professional experience functioned as a searchlight: it made him focus on the design of the technology design and the user experience. He focused on the environment in which the technology would be used and how the interaction between the user and the medical staff would work. He wonders what a trustworthy relation between the technology and its user would look like. This fragment illustrates how the participant's background in interaction design influences the questions that the installation raises for him. The following fragment shows a similar mechanism of the impact of medical doctor's professional experience on the reflection process:

Fragment 14

He talked a lot about what the situation will look like in the hospital. He described the current situation with rooms for both parents and the child and questioned how the design could have a place in there [...] He had a lot of questions: if the artificial womb technology were realised, what would it look like? He explained that in his hospital they aim to facilitate family interaction; so, one room hosted one set of parents and their child or children. He was concerned about its acceptance in society, including the acceptance of the costs, and that it would not immediately be for everyone.

This fragment, like the previous one, shows each participant's focus on potential users' experience that directly relates to their professional experience as a designer and doctor respectively. This participant was preoccupied with the position of the artificial womb in the hospital room, which directly corresponds to the focus of the hospital where he works to facilitate family interaction. His reflection on healthcare costs and accountability towards society also seems to be directly related to his professional background as a medical doctor.

These fragments illustrate how participants' personal or professional experiences set the course of their reflection process initiated by the design installation. Their personal experiences informed what participants saw in the installation and what they reflected on. Depending on their experiences, participants saw in the installation a tool to serve what they saw as egocentric motives (fragment 11), a technology–user relation to be designed (fragments 12 and 13), and an instrument embedded in a democratic society (fragment 13). Personal and professional experiences function as a searchlight, giving focus to reflection and inviting a certain set of follow-up questions and scenarios while leaving out others.

5. Discussion

5.1. Pragmatist ethics

Artificial womb technology is currently being developed, however, there are no concrete products or services yet available in society. Therefore, there is no Deweyan passive protopublic being indirectly affected by this technology at this point in time. The absence of concrete products and services in the real world may explain why some visitors did not engage with what-if questions. As [Kupper \(2017\)](#) described "civil society actors might not be motivated to have future emerging technology as a topic for deliberation and reflection as there is nothing yet at stake for them". In order to have a reflective inquiry about this emerging technology a speculative prototype was realised for visitors to anticipate indeterminate situations and identify the associated passive protopublic. The ambiguity of the installation created the conditions for a potential protopublic to emerge. Visitors actively filled in the narrative gaps of the installation with their own perspective, thereby fulfilling an active role in designing the indeterminacy and associated passive protopublic. Also the organisers of the installation had an active role in forming the protopublic by determining the anticipated look and feel of the future. Visitors did not reflect on a currently existing issue affecting them as a passive protopublic, but were informed by the design of the installation about possible indeterminate situations. Speculative design is a promising tool to facilitate the formation of a protopublic around an issue in the Deweyan sense of the word ([Marres, 2005](#)), by making issues tangible when nothing is at stake yet. The interventionist character of speculative design is not as different from processes in which publics organise around issues as described by Dewey. For Dewey as well, it was evident that most publics do not organise themselves; representatives play an important role in identifying issues and organising publics ([Brown, 2009](#); [Caspary, 1991](#)).

The following paragraphs will elaborate on the ways in which our results show how elements of pragmatist reflective inquiry can be facilitated by speculative design. More specifically, four key elements of dramatic rehearsal as conceptualised by [Cuhls and Daheim \(2017\)](#) will be used to discuss this ability: exploring possible lines of action, responses of other persons and oneself, creative reconceptualisation and indeterminateness, open-endedness, and risk.

A first feature of dramatic rehearsal is the imaginative evaluation of possible consequences of possible lines of action that are of a qualitative nature ([Cuhls & Daheim, 2017](#)). What is needed for participants to create possible lines of action? The first reflective practice described the process of questioning assumptions about established human–technology relations. Speculative design's ambiguous appearance required participants necessarily to become creative moral agents. As discussed in the previous paragraph the ambiguous character of the installation created the conditions for visitors to form protopublics. Alongside, the narrative gaps to be filled in created space for participants to integrate personal experiences, references to existing practices or technologies, and moral principles from different ethical theories in their moral deliberation. Each participant brought in elements that made scenarios twist and turn in unique ways, which generated a rich and nuanced variety of meanings. Rather than following a well-trodden path to a clear-cut moral valuation, participants arrange these elements in new combinations that require their moral scrutiny.

A second key feature of dramatic rehearsal is the anticipation of others' and one's own responses to various acts and situations ([Cuhls & Daheim, 2017](#)). The process makes participants discover moral beliefs of which they were previously unaware. Our findings show the potential of the installation to engage visitors in a dialogue exchanging perspectives of possible responses, either with the visitors they came with or with unknown visitors. This direct interaction with others is important in Dewey's moral reflection as engaging with other perspectives makes you question your own, enables you to wonder and learn more about the multifaceted moral issue at stake. Additionally, our findings reveal that the installation triggered participants to anticipate potential responses of a wide variety of stakeholders. The conversational fragments showed participants exploring the needs and desires of 'career' (professional) women, emancipated women, future parents, and same-sex couples, among others. At times, this anticipation lacked depth. Moral exploration did not always reach beyond stereotyping and exaggerated motives and desires, which are easier to embrace or reject (e.g. 'evil dictators creating soldiers in artificial womb factories'). These reflections did not search for Deweyan solutions to moral problems as he described in the second phase of reflective inquiry ([Kupper, 2017](#)). Rather, this type of reflection is an elaboration of the first phase of reflective inquiry in which problems are articulated. The question arises why some reflections did not reach the final stages of Dewey's reflective inquiry. One may argue the imaginary character of the installation in a far future setting does not bring across a sense of urgency or indeterminacy required for a reflective inquiry. Another reason could be that these visitors are not affected by the issue and therefore are not the passive protopublic and not in a reflective inquiry in a Deweyan sense. Or, maybe visitors actually did provide solutions. Not in the form of statements but rather in the form of questions that would arise in their preferred course of the future. One possible example is the nuanced reflection in fragment 10 in which the participant speculated about the role of future parents and the time they'd refer a child to the municipality, which made him question his own ideas of what it means to be a human being.

A third important feature is a process of creative reconceptualisation. In pragmatism, concepts are not static. They are considered important instruments in deliberation by helping us to identify, order and interpret what is at stake ([Cuhls & Daheim, 2017](#)). They are, however, subject to change as new developments, such as technological innovations, question their meaning. Throughout the process

of generating scenarios participants questioned concepts of personhood, gender roles, reproductive rights, technology-mediated responsibility and justice. The concepts gained new meanings or established meanings were questioned within a context sketched through scenarios. The contextualisation was not merely an instrument that enabled participants to reason about the abstract definition of the concepts. Rather, they obtained meaning through the contexts of which they were envisaged to be a part. Thus, the speculative future the installation presents allows for participants to generate scenarios through which they can challenge and question concepts in a meaningful, contextualised way.

According to [Cuhls and Daheim \(2017\)](#) there is one fourth characteristic underlying the other features, namely the open-ended character of deliberation. The installation's open-ended character leaves it up to participants to determine what actors are involved, how the technology will be used and what society will look like. As a result, participants developed a rich variety of scenarios in which unexpected twists and turns challenged values and interests of those involved. That this creative process requires effort and involves risk became clear from participants' search for guidance in the form of scientific facts. Participants aimed to determine the border between reality and their imagination by asking the guides about the scientific validity of the installation. Sometimes this 'reality check' took up the conversation and hindered participants from using their own imagination. Dewey stresses the need to include (scientific) facts and findings in our moral deliberations ([Caspari, 1991, p. 186](#)), but that they are not sufficient to determine our decisions. Rather, they should be used as intellectual instruments for inquiry. Our findings show that speculative design has the potential to take new scientific developments as a starting point and spark conversations about what it means to be a human being, and what an ideal future society looks like.

5.2. Public dialogue

Our findings on the induced reflective practices and the discussion of speculative design's potential to put pragmatist dramatic rehearsal into practice enable us to assess how it addresses the shortcomings of current public engagement initiatives. The introduction described how current initiatives tend to focus on quantifiable rather than qualitative impacts and include abstract reasoning rather than other forms of knowledge exchange. In addition, deliberators find it difficult to imagine potential 'tech futures' and to take on the perspective of others. Finally, the public opinion is often regarded as a static given rather than the result of an active co-creative process. We mentioned that some work on developing more reflexive public dialogue initiatives has been conducted, such as the use of techno-moral scenarios and the incorporation of emotional and creative forms of communication ([Swierstra, Boenink & Stemerding, 2010](#); [Davies, 2014](#)), but that practical aspects of methodology aimed at reflexivity remain underexplored. With regard to the shortcomings of initiatives, our findings show that speculative design has the potential to spark reflection in a wide variety of knowledge forms, for example, by creating space for personal experiences and emotional responses. It provides a safe space in which to explore a set of scenarios in which qualitative impacts of all sorts (cultural, moral and political) can play a role. The installation encouraged imagining futures by providing thought-provoking potential. In using speculative design for the purposes of public engagement, however, it should be taken into account that some participants feel more comfortable with using their imagination than others. Also, although participants took on others' perspectives, in line with previous findings in literature ([Macnaghten et al., 2010](#)), this reflection lacked depth at times because of their reliance on one-dimensional stereotypes. Finally, the speculative design practice does not regard the participants' opinions as static. Rather, the ambiguous installation required participants (often without any prior knowledge on the topic) to go through a creative inquiry requiring continuous input and reflection to give shape to their perspective. In answer to [Roeser et al. \(2018\)](#) call for new frameworks and perspectives, we can conclude that the pragmatic notion of dramatic rehearsal offers a valuable framework for interpreting speculative design as a method of facilitating public dialogue in the context of reproductive technologies.

Despite the potential of speculative design to address the shortcomings of current public dialogue initiatives, the medium has its own limitations. Our findings reveal a tension between informing participants while also encouraging them to use their imagination. Participants expressed a desire to be informed about the scientific underpinnings and limitations of the technology in order to make a meaningful ethical deliberation, while the very ambiguity of speculative design is crucial for encouraging participants to develop ideas and perspectives. Our findings indicate that sharing too much information might make participants passive listeners rather than creative moral agents, while sharing too little information fuelled frustration and led to un- and misinformed participants. This tension in speculative practices concerned with the future of emerging technologies is also addressed in other literature. [Partridge, Davey, and Hornick \(2017\)](#), for example, criticises speculative nano-ethics for endorsing or critiquing nanotechnology on the basis of ethical considerations based on far-fetched futures. Instead, he argues, nano-ethics should be concerned with questions about actual nanotechnology designs and applications. According to [Haidamous \(2017\)](#), by rejecting speculative nano-ethics [Partridge et al. \(2017\)](#) neglects an important aspect of such speculation. Incredible speculative futures might not be suitable for making an ethical assessment of the technology itself, but because these are necessarily constructed on the basis of our current knowledge, fears, values and expectations, they are an important source for an 'explorative philosophy' that assesses not the acceptability of the technology, but the quality of various imagined futures. This is in line with [Dunne and Raby \(2014, p. 6\)](#), who intend to use speculative design not to predict the future, but to 'open up all sorts of possibilities that can be discussed, debated, and used to collectively define a preferable future'. As also became clear in our research, it is therefore not only the future we explore with speculative design but ultimately our existing values and fears.

5.3. Future research

As emphasised in the introduction of this article, much academic focus has been directed at the perspectives of designers, politicians

or the products of co-creative design sessions. Only a limited number of studies explored the experiences of those interacting with design. Grunwald (2010) performed a thorough theoretical analysis on characteristics contributing to participants' reflective practices. Our study validates and enriches their conclusions with empirical findings. The authors highlight the importance of storytelling, speculative futures' relation to our 'everydayness' and the presence of emotional responses in reflective practices, concepts that one can recognize in our analysis on participants' dramatic rehearsal, participants' use of stereotypes and familiar ways of doing things and emotional responses as a part of lived experiences. Future research is needed to validate our findings and further specify the enabling factors and three ways of questioning human-technology relations. More specifically, additional research should bring together what various studies have done separately, namely exploring the relation between design characteristics and their effect on participants' deliberation. In that way, science communicators and speculative designers looking to use speculative design as a tool to foster public engagement could be guided in crafting and putting this medium into optimal use.

5.4. Limitations

An important limitation of the study is a result of the procedure we adopted for recording the conversations with participants. Due to the challenging acoustic conditions around the installation, we decided to record summaries of the conversations immediately after, instead of recording the conversations directly. Even though the researchers aimed at summarising it as factual as possible, some personal interpretation is unavoidable which might have affected the validity and reliability of the data.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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