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Welcome to the fertility clinic of the future! Using speculative design to explore the moral landscape of reproductive technologies

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The evolving field of reproductive technologies greatly alters our practices of conception and pregnancy. It is thus crucial to develop such innovations in a democratic and sustainable manner through public participation. To date, participation has mostly focused on patients or health professionals deliberating on technological risks, benefits, costs, and healthcare experiences. Thereby, the opportunity is missed to consider broader social and moral implications. Speculative design has been presented as a promising way to open up deliberation on the impacts of new technologies. In this study, speculative design was used to gain insight into citizens' views and concerns about the social and moral implications of the new reproductive technologies. Six themes of concern were found: the rights of the unborn; access and equality; social implications of individual choices; society as a community; ecology; and the value of wonder. Notably, the latter two issues are not commonly described in the participatory literature on reproductive technologies, indicating that speculative design is suitable for broadening the debate by including issues that have not been addressed yet. Furthermore, the study brought insight into the motivations and complex values that lie behind arguments in which the naturalness of reproductive practices is emphasized. A point of critical reflection is that to broaden the range of reflections probed by speculative design even more, both the designers and the audiences should become more diverse. If this is achieved, it is suggested using speculative design in the context of public deliberation with a more direct influence on innovation trajectories and as a means for the public to become more skilled in critically engaging with imagined futures.

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Introduction

The field of reproductive technology is rapidly evolving and may greatly alter our practices of conception and pregnancy. In vitro gametogenesis (Makar and Sasaki, 2020), genome engineering (Vassena et al., 2016), mitochondrial donation (Dimond and Stephens, 2018), human germline genome editing (Kaur, 2021a) and extra-uterine support systems (Partridge et al., 2017) are just a few examples of the multitude of innovations that are being developed. As a topic of discussion, reproductive technologies are, however, extremely politically sensitive as they (1) touch upon issues of reproductive rights (Bryld, 2001; Rothmar Herrmann and Kroløkke, 2018; Sheller, 2020); (2) change legal concepts like professional liability, privacy and bodily integrity (Crockin and Jones, 2010); and (3) require us to reconsider widely held categorical distinctions through which we see and act in the world, such as between human beings and machines, being alive or dead, male or female, and naturally grown and artificially created (Shalev, 2015; van Beers, 2016).

It is thus crucial that such reproductive practices are developed in a democratic manner through public participation. By gaining experiences, concerns, and knowledge about reproduction-related issues in society at large, reproductive technologies can be more attentively aligned with societal needs and concerns (Stilgoe et al., 2013; Stirling, 2008). Through public deliberation, technological trajectories can incorporate social values other than the scientific, medical and commercial values that dominantly drive innovations (Jasanoff, 2007; Lehoux et al., 2012).

A growing body of literature focuses on public perceptions and attitudes toward new assisted reproductive technologies and practices. These studies focus on a wide variety of such technologies or practices, for example, in-vitro fertilization (Boueilh et al., 2018; Silva and Barros, 2012) stem cell-based fertility treatment (Hendriks et al., 2017), (paid) gamete donation (Goedeke et al., 2020; Hudson, 2020; Kaya Şenol et al., 2019; Villalona, 2019), prenatal genetic screening (Iredale et al., 2006; Mosconi et al., 2018; Napolitano and Ogunseitan, 1999), pre-implementation genetic testing (Cox et al., 2009), mitochondrial donation (Herbrand and Dimond, 2018; Newson et al., 2019) embryonic research (Matthews et al., 2021) or cryopreservation (Baldwin et al., 2014; Inhorn et al., 2022; Stormlund et al., 2019), while only a few focus on the more general implications and perceptions of a broader range of assisted reproductive technology taken together (Kaur, 2021b; Knecht et al., 2011; Queiroz et al., 2020; van Kammen et al., 2006). What stands out in this body of literature is that most studies include attitudes or perceptions of a specific group of people: potential or actual patients for example (Baldwin et al., 2014; Goedeke et al., 2020; Herbrand and Dimond, 2018; Hudson, 2020; Inhorn et al., 2022; Kaur, 2021b; Silva and Barros, 2012; Stormlund et al., 2019), or others that are involved in the use or policymaking of assisted reproductive technologies (Boueilh et al., 2018; Iredale et al., 2006; Kaya Şenol et al., 2019; Knecht et al., 2011; Matar et al., 2019; Queiroz et al., 2020; Silva and Barros, 2012; van Kammen et al., 2006; Villalona, 2019). Fewer studies are interested in including the perceptions of citizens as citizens (Cox et al., 2009; Fauser et al., 2019; Hendriks et al., 2017; Hodgetts et al., 2014; Iredale et al., 2006; Mort et al., 2016; Mosconi et al., 2018; Napolitano and Ogunseitan, 1999; Newson et al., 2019). In most of these studies, however, participants are consulted with quantitative methods such as surveys (Fauser et al., 2019; Hendriks et al., 2017; Mosconi et al., 2018; Napolitano and Ogunseitan, 1999), which allows only for gathering input on predefined problems and with a limited set of answers to fixed questions, or researchers started from a specific problem framing such as an economic (Hodgetts et al., 2014) or risk (Mort et al., 2016) perspective. Studies that are interested in qualitative insights into the topic instead, typically obtain those through cultural and conceptual analysis of policy and debate (Baldwin et al., 2014; Bryld, 2001; Dimond and Stephens, 2018; Franklin, 1990, 2006), through patient interviews (Hudson, 2020; Silva and Barros, 2012) or through ethnographically studying practices of such reproductive technologies (Inhorn et al., 2022; Inhorn and Patrizio, 2014). Only a handful of studies are explicitly organized around an open form of citizen engagement with the aim of triggering participants to deliberate on the (qualitative) impacts of such new reproductive technologies (Cox et al., 2009; Iredale et al., 2006).

Our study was a citizen engagement project that aimed to open up the understanding of "the public good" beyond affordable and safe healthcare interventions in the debate on emerging reproductive technologies. As Jasanoff (2007) notes, when persuasive social and technological imperatives operate together, they tend to legitimize technology-related policy. We should remain alert to the danger that participatory approaches follow the same imperatives they aim to question. The range of moral implications that we are interested in in this study is thus much broader than costs, health, and patient and professional experiences. We have adopted a pragmatist understanding of morality, in which morality pertains to our relations with others around us and our convictions of what the good life entails. Morality is often implicit; moral norms shape our practices, our daily lives, our expectations, and our relations with others without us giving it much thought. In this view of morality, it does not denote a set of procedures, rules and heuristics that help us determine the morally right decision, but the diverse moral practices and routines in which we, as 'beings for whom things matter' (Sayer, 2011, p. 19), engage with the people around us (Willems, 2021). This is in line with Swierstra and Te Molder (2012) who use the term "soft impact" for the effects technologies have on our conceptions of the good life, our relations with others and the meanings and world views that structure our behaviour. They are thus qualitative rather than quantitative, ambiguous due to unclarity about the underlying values, and they are not simply caused by technology but are co-produced in the way individuals or society uses these technologies (Swierstra, 2015). In the context of this study, soft impacts are, for example, how reproductive technologies change our thinking about fate and suffering, and how they co-shape our identities, our aspirations, our social relations, and our understanding of nature. These are more complex, but hugely important for policymakers and politicians to take into consideration (Jasanoff, 2010; Swierstra, 2018).

On a similar note, deliberation on specific technologies in isolation ignores how a manifold of technological possibilities in reproductive practices interact and fundamentally shapes our reproductive future. As Felt (2015, p. 121) fairly points out: 'public choices are not for or against technology but for or against particularly imagined forms of life'. In order to spur participants' imagination about the soft impacts of a broader set of reproductive technologies we adopted an orientation to the reproductive future, which allows for collectively exploring the complex reality of an indeterminate situation such as the introduction of new technologies into society (Kupper, 2017). In our pragmatic view, morality is distinct from ethics. Whereas the former often stays implicit in what we say and how we act; ethics is the critical and explicit reflection on morality, which is prompted by conflicts or dilemmas that arise (Kupper, 2017; Swierstra et al., 2009). By presenting a diverse range of reproductive technologies set in the future, we attempted to spur reflection on future soft impacts, i.e., we tried to go from reproductive morality to reproductive ethics. This meant the focus was on the kinds of concerns and opportunities that appear to citizens when confronted with the possibilities, rather than systematically

Table 1 Description of the exhibits in Reprodutopia.

Exhibit name	Description
I wanna deliver a dolphin	Video-installation showing a video of 2.40 min of a woman giving birth to a dolphin. This exhibit raises questions about overpopulation, endangered species and responsibility for life.
Lab romanticism	Round wooden frame ø 30 cm, filled with marbles, five glass bowls and two marbles. The exhibit represents a ritual for parents conceiving through IVF. This exhibit raises questions on what intimacy might look like when conceiving a child through reproductive technologies.
Mono Parenting Kit	White cardboard box of 20 × 30 × 10 cm with the in vitro fertilization of a cell and instructions on how to Do-It-Yourself. The graphic design gave it the appearance of a contemporary technology company packaging. This exhibit raises questions on genome engineering, and new forms of genetic parenthood such as mono-, or poly-parenthood.
Virgin Parent Ring	An engraved ring in a jewellery box covered by a glass bell-jar. The exhibit suggests that combining the reproductive technologies IVF and the artificial womb could give rise to 'virgin parents'. The exhibit raises questions about the role of rituals, culture and religion in the development of reproductive technologies.
Reunion Network	A table with three mobile phones displaying the mobile app 'Reunion Network'. Visitors were able to design a pedigree of valuable personal relationships. The exhibit raises questions about kinship, what it means to be family and whether being human is a requirement.
Youterus	Wearable mobile womb prototype made of a hard-plastic sphere and Velcro ties to be attached around the waist. The exhibit raises questions about bonding between mother and child, femininity and fatherhood.
Artifical Womb	Five red balloon-like spheres arranged above a pink ground plate of 2.5 × 2 m. Attached tubes and cylinders give the exhibit a clinical appearance. The exhibit raises questions about human–technology relations, pregnancy and parenthood.
Pig Womb	Wooden children's puzzle of a pig carrying a human baby. The exhibit raises questions about human–animal relations, xenotransplantation and surrogacy.

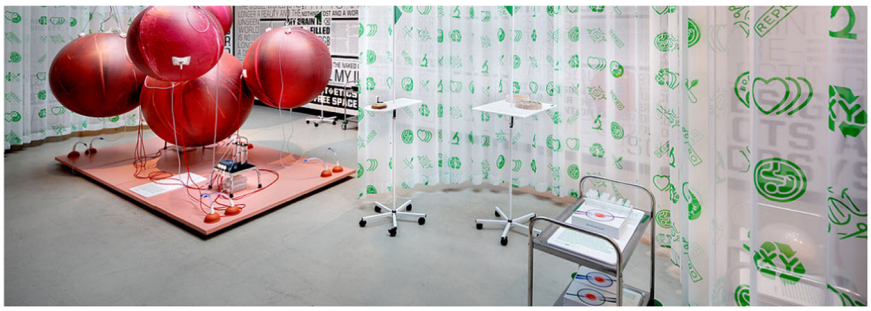

Fig. 1 Reprodutopia. A speculative design mobil clinic placed at @droog. From left to right the exhibits 'Artifical Womb', 'Virgin parent ring', 'Lab romanticism', and 'Mono-parenting kit'.

arguing about the ethical consequences of such technologies within current legal possibilities. Note that going beyond the current legal possibilities is crucial because, in this process of socio-technical development, the norms and values that we are accustomed to in order to assess new technologies are often destabilized when such technologies emerge. For example, new distributions of responsibility might become accepted, new actors become of concern in new ways or the nature of relations between people changes. This is what Swierstra (2013) calls "techno-moral change". Due to the unpredictable and open-ended nature of this process, it is important to go beyond what is legally allowed and also discuss what is not (yet) allowed.

Speculative design has been presented as a new and promising way to open up deliberation on the subtle ways in which technologies influence the way we live and act in the world (and vice versa) (Fraaije et al., 2022; Heidingsfelder et al., 2019; Kerridge et al., 2008). Typically, speculative designs are fictional objects positioned to function in mundane contexts in order to question the impact of applied science (Malpass, 2013). In showing a fictional technological element in an everyday context, they stimulate people to imagine the implications of this type of technology in our daily lives, now and in the future. Speculative design is claimed to have the potential to (1) arouse interest in abstract fields of new and emerging technologies through its visual representations, enriching predominantly text-driven forms of science communication (Heidingsfelder et al., 2017, 2019); (2) promote inter- and transdisciplinary communication by encouraging collective reflection on the proposed possible future, and providing the opportunity to disagree (Heidingsfelder et al., 2017, 2019; Selin et al., 2017); (3) aid imaginative thought through its open-ended character, thereby unleashing the imaginary power that is needed to envisage future scenarios (Dunne and Raby, 2013; Felt, 2015; Nabuurs et al., n.d.); and (4) encourage moral and emotional deliberation on technology as it can tap directly into the senses and help people to express what is obscure (Flint, n.d.; Fraaije et al., 2022; Selin et al., 2017).

With this study, we aim to gain insights into the ethical reflections that emerged among citizens in a speculative design exhibition, 'Reprodutopia', on innovative reproductive technologies. As such we also examine the added value of the method used in this study, speculative design, in opening up the discourse on reproductive technologies to soft impacts and explore citizens' reflections on reproductive technological developments.

Methods

Data collection. The speculative design exhibition 'Reprodutopia' was a speculative mobile clinic, in which visitors were invited to explore the future of emerging reproductive technologies, such as an artificial womb, in vitro gametogenesis, gene editing and embryo screening and selection (for a more extensive description, visit: https://Nextnature.Net/Projects/Reprodutopia). It displayed several exhibits (Table 1) under which the 'Artificial Womb' (Fig. 1), 'Youterus' (Youterus, 2022) (Fig. 2), 'Pig womb' (Fig. 3), 'Mono-parenting kit' (Fig. 4), 'lab romanticism' (Mandemaker,

Fig. 2 Youterus. Visitor wearing the exhibit.

Fig. 3 Mono-parenting kit. Researcher in the role of consultant, holding a kit.

Fig. 4 The pig womb.

2022), and 'I wanna deliver a dolphin' (Hasegawa, 2022). The tags displayed in the exhibition can be found in Annex 1.

The exhibition was located at the design gallery @Droog in Amsterdam during October and November 2019. The clinic was designed by speculative designers' collective Next Nature Network, which aims to 'explore how technology becomes so omnipresent, complex, intimate and autonomous—a nature of its own' (Next Nature, n.d.)

Interviews were designed to be an integral part of an exhibition that would open up imaginations on acceptable reproductive futures. The first three authors conducted semi-scripted interviews with exhibition visitors. The interviewer firstly addressed visitors in the role of a speculative consultant, thus being part of the interactive exhibition design. As a speculative consultant they asked visitors whether they would like a tour through the fictitious clinic. Then, as a researcher, they explained the purpose of the interview, and asked whether they gave permission to record their responses and to use the anonymously stored data for later publications. In the very few cases where children were part of the interaction their parents were also present, and they gave informed consent for their children's participation in the tour. In this way we could record and thus include the parents' interactions but we excluded the input from the children from our analysis and from the writing.

We call the interviews "semi-scripted" instead of "semi-structured" because the conversations started with a short script enacted by the interviewer. They would open the conversation by welcoming the visitor as follows: "Welcome to the reproductive clinic of the future. It is 2050 now and there are no biological, social or technological barriers for how you want to carry your baby or how you want to build your family". The consultant and visitor then engaged in a dialogue about what the visitor's preferred future would look like in relation to reproduction. The reflections were guided by questions, such as 'Would you like to try our prototype?' and 'How will the widespread use of this technology affect our perception of gender?' The interviewer focused on deepening the reflections on initial assumptions and emotional as well as on fantasy-based responses, mostly by asking clarifying questions. Interviewers steered the conversation back to reflections on the speculative design probes, and on what (in the exhibition) triggered visitors' responses and reflexive thoughts. During the interviews, the interviewer switched between the roles of speculative salesperson and consultant, philosophical inquirer and ethicist, and equal conversation partner and devil's advocate.

A total of 67 conversations with 142 visitors were held. Consent was given to record these conversations and use the data for research purposes. The conversations lasted for an average of 30 min, ranging from 10 to 77 min. Interviewees could withdraw

from a conversation at any time, which happened on two occasions. Interviews were held with individual visitors, pairs or small groups of four to eight persons. Interviewees' age ranged mostly 30–50 years of age; varied in sex, although most were female; and were in general culturally interested. Most interviewees visited the exhibition by chance, either from looking through the window or visiting the @Droog café. The visitors' nationalities varied; they came from a diversity of Asian, as well as European, North and South American countries due to the fact that the exhibition site is located in Amsterdam's city centre, attracting many tourists, (art school) students, and foreign residents.

Analysis. The interviews were transcribed verbatim and analysed by the first author using MAXQDA18 software. Analysis consisted of two rounds. First, a thematic analysis was done based on the techno-moral patterns and tropes developed by Swierstra and Rip (2007) and (Boenink, 2010) was undertaken. These patterns, known from past techno-social-moral deliberations, include eight topics about the impacts of new and emerging technologies, which might

1. enable unintended forms of use and users
2. change roles and responsibilities
3. change standards of normalcy
4. make specific stakeholders caused by the new technology
5. create new rights and obligations
6. create specific groups of haves and have-nots through the introduction of the technology
7. render older routines to become superfluous and cause processes of deskilling
8. lead to a revaluation of the problem because of a new technological lens or approach

Secondly, we analysed the contextual information in discussing these patterns. By analysing interviewees cultural, personal, or imaginative associations, we gained insight into worldviews and underlying values. This enabled us to identify relevant questions and reflections of the interviewees with regard to the responsible development of reproductive technology. In a final step, the main lines of reasoning and questions for responsible technological development were themed deductively in a round of open coding. Not that we were not concerned with establishing a representative sample of participants' convictions, but to explore, understand and cluster a diverse set of reasonings and reflections. This led to the six themes as described below. Regularly, between and after each round of coding, outcomes were discussed among the first four authors. Disagreements were resolved by negotiation until the recognized patterns were agreed upon.

Results

We found six recurrent themes regarding moral concern in developing reproductive technologies, on which the Reprodutopia visitors reflected. These are:

- *the rights of the unborn:* reflections on the basic needs of the unborn's life, and how to balance these needs with those of future parents;
- *access and equality:* the question for whom reproductive technologies are, or for whom they should be developed;
- *social implications of individual choices:* the tension between the value of autonomy and the influence of individual choices on society; it involves the question of to what extent we can interfere in this sphere of other people's lives, and related to that, how much about this part of one's life we should share publicly;
- *society as community:* reflections on the society we live in, and the society we would like to live in, in relation to sharing the responsibility and care for newborns;
- *ecology:* reflections on the relationship between species, and caring for the planet; and
- *the value of wonder:* the question of how to protect the value of wonder.

We will elaborate on the reflected values and concerns, and the questions that should be considered in developing reproductive technology responsibly.

The rights of unborn. In Reprodutopia, by far the most common interest considered was that of the unborn child. To determine what is in the best interest of the unborn, visitors of Reprodutopia reflected upon the question 'what does a child need growing up?'. Two particular needs were mentioned: the right to identify as a unique individual and, the right to a sense of belonging. However, what was meant with these concepts differed, as the following example illustrates.

Many visitors brought up the topic of cloning in order to make a claim for the importance of identifying as *a unique individual*. Mostly triggered by the 'Mono-parenting kit' exhibit, visitors reflected upon the implications of selecting and copying genetic traits for the rights of the unborn. Some visitors mentioned that in order to experience being an individual, it is important not to feel like a copy of one's parents (or any another human being). They argued that it is most important that a future life should be able to separate itself mentally from the people that 'made' the person.

Besides the need for a sense of self, the need for a *sense of belonging* was emphasized. According to many visitors, what should be protected is having knowledge of one's social, physiological and/or biological line. For some visitors this first and foremost referred to the importance of children being brought up by loving people. For others, however, knowledge of a biological genetic line was more important. Mostly triggered by the 'Mono-parenting kit', as well as by the 'Artificial womb' and 'Youterus', reflections revolved around the consequences of a lack of sense of belonging when a child grows up; the comparison with adoption and sperm donation was drawn on numerous occasions. For example, a visitor brought up her sociological research into sperm donation, to indicate how strong the desire for a sense of belonging can be:

> 'I did research on sperm donor children for a little while in my sociology programme and we studied kids who once they turn 18 met their sperm donor […] for instance, children who, or had Christian parents, but they knew that their sperm donor was Jewish so they took on a Jewish identity. And sometimes after meeting the parent, the sperm donor, find that Judaism has no significance to the sperm donor but this, the child had taken on a real Jewish identity.' (P1)

Some visitors saw opportunities in reproductive technologies, as they argued it would be easier to ensure children would know their genetic history. Others brought up concerns about how the ease by which such technologies can be used, might induce non-transparency and carelessness when it comes to knowing and sharing information about genetic relations.

All in all, Reprodutopia visitors emphasized that in order to develop reproductive technology responsibly, it is important to deliberate collectively on the following questions: How do we ensure the development of a sense of self and belonging in a future life? How do we ensure that these people can live free lives and that they are not discriminated against because of the way

they were conceived or born? And, how to stay aware of the needs of the unborn when technological possibilities change?

Access and equality. The question for whom reproductive technologies should be developed was another recurrent topic of reflection. In reflecting on increasing equality and accessibility of reproductive technologies, visitors reflected on how it would be important to assure equality in access to such technologies and how to make sure this would not become to expensive. Besides such questions, visitors reflected on the question for which groups the technologies would make parenthood accessible. Several categories of (groups of) people were often named: gay couples, people who are physically unable to conceive, carry or give birth to a child, single women who want to have children, people who have strong ambitions in the field of public work, transgender people, people who want to experience what it is like to be pregnant, or want to remember what it was like, people in countries with poor healthcare infrastructures, men, poly-amorous couples and groups of friends. While standing in the imaginary clinic, many visitors were also wondering who should *not* have access to reproductive technologies. Groups of people that were named in this case included people who are too old to be a "proper" parent, people who are addicted to alcohol or hard drugs, people with too busy a lifestyle, who are unwilling to make compromises in their life.

In trying to answer the question of who should be allowed to use the reproductive technologies depicted in Reprodutopia, some of the categories and labels that we attach to groups of people were investigated and redefined. A clear example of a category that visitors reflected upon was the variability of age as a relevant criterion. Some visitors mentioned there should be an age limit to the use of reproductive technologies, others thought it would be a good opportunity for people to become a parent at an older age when they have the time and patience to be a parent. Where to draw the line when age becomes a problem, appeared ambiguous. For instance, one visitor came up with the definition of being allowed to use this technology within: 'the borders of the age that you are still flexible' (P2).

Furthermore, in deliberating who should fall within the new reproductive standard, it was frequently stated that if technology offers the possibility for everyone to have children, biology can no longer be a reason for discrimination. At the same time, many visitors felt that parenthood offered by a heterosexual couple offers a child the most social stability.

Overall, questions to be asked in developing reproductive technology responsibly are: How do we ensure that technology is not solely developed for people who fall within 'the norm'?, How can technology development link up with social development towards equal rights across sex and sexual preference? And how do we ensure that reproductive technology does not increase existing inequality?

Social implications of individual choices. Another frequent topic of conversation was the tension between the value of equal access to technology and the potential negative consequences of such access to society. So, universal access to reproductive technology is easily referred to as being utopian, but visitors also often emphasized that if one is able to reproduce in the 'natural way' one should continue to do so. In Reprodutopia the trade-off between autonomy and control became apparent

> 'It would be incredible if it [reproductive technology] allows one day all the people that want to have a child, to have a child. Whatever gender, age, medical condition, character or societal pressure and culture. […] I think we should never forget what's the natural, original way of reproducing. it should remain the most common and normal way to make babies. I think technology should be used as a help for people that cannot have a child for psychological or physical or medical reasons, but the natural way should remain the standard. And most widespread one.' (P3)

In line with the autonomy argument, Reprodutopia visitors, for instance, often stressed that the choice for a particular way of reproduction feels as, and should remain, private. Often triggered by the 'Virgin parent ring', visitors expressed the need to be able to make individual choices about something as personal as reproduction, and subsequently to keep those choices private (e.g. not share them digitally or virtually). However, as illustrated by this visitor, it was also pointed out that these desires at an individual level can lead to undesirable public spaces:

> 'I find that very private and intimate how you give birth to your child. That's a thing you don't have to show in public. [...] But the public domain is becoming more sterile because everything human, such as birth and growing old, is no longer visible.' (P4)

Besides the importance of privacy, it is generally stated that everyone should be able to choose for themselves what customs they use before, during and after pregnancy. However, again comments such as 'everyone should decide this for themselves' were immediately interspersed with comments such as 'we must ensure that we do not disrupt society'. In particular, visitors foresaw that as opportunities grow and reproductive technologies become more easily accessible, the ability to make conscious choices could diminish. Visitors started to wonder to what extent people are able to make autonomous decisions considering the inevitability of societal values. Making for instance comparison with plastic surgery, they mentioned how norms appear to be subject to constant change. To counter the threat of underestimating parenthood, a regulatory measure that was frequently mentioned was 'a parenthood test':

> 'We do have to do some kind of test beforehand [before using the poly-parenting kit] to see that you have good relationships with each other and not just do it as a drunk fun thing. It should be like a real decision. […] We need to have some kind of check. Some kind of threshold to see if you are serious.' (P5)

Whereas some visitors envisaged that taking away the '*suffering*' of being pregnant might normalize careless decision-making, others envisaged a future in which the increasing possibilities of reproduction for a wider diversity of people would make it possible to decide more consciously to have children.

Questions we should ask ourselves about the tension between individual choices and social consequences in the design of the infrastructure in relation to reproductive technology are: How to encourage conscious decision-making as potential future parents? How do we ensure that what we develop does not have a negative effect on society?

Shared society. Related to this, visitors reflected upon what kind of society we want to live in. Visitors mostly reflected on Western society; how it is rushed and individualized, overvaluing efficiency, and how this individualism affects people and the way they live. Often Reprodutopia visitors talked about the importance of paying sustained attention to others, especially children, who are alive today and need to be cared for; and the importance of having the space and time to experience things together, and to be in close proximity to one another. What are the essential parts of 'family' and 'parenting'? These reflections arose when talking

about new forms of family composition (e.g. forming a family with friends) sparked by the 'Reunion Network' exhibit as well as the 'Mono-parenting kit'.

An important element within this concern for a shared society relates to safety and feeling safe in a community. For some visitors, this meant supporting each other during pregnancy and raising children:

> 'This does not necessarily have to be done by all wearing the portable 'Youterus', you can also support each other in other ways' (P6)

Particularly when deliberating on the 'Mono-parenting kit' and 'Reunion Network' exhibit, and new family and parenthood forms, people wondered what a good way is to take on joint responsibility for the care of children. One Reprodutopia visitor, for example, stated that feeling safe to her meant not being the only one held responsible for the parenting decisions she would have to take. She expressed the need to share the responsibility of reproduction and educating children, while others expressed the need to make autonomous decisions regarding the upbringing of their children in order to feel safe in society.

The questions that visitors bring to the centre of their attention are: What is needed to develop good relationships? How to share responsibility for future life?

Ecology. Questions such as who takes responsibility for taking care of the (new) life did not only revolve around human beings but also concerned animals and plants. Mostly triggered by the 'Pig womb' and 'I wanna deliver a dolphin' exhibit, people empathized with animals and brought up their rights. For example, the 'deliver a dolphin' exhibit, one visitor reasoned that we should think about the environment in which animals live. This visitor notes that we need to take a holistic perspective and that thinking of reproduction, and reproductive technologies, only in terms of 'birth' is shortsighted:

> 'I think [giving birth to animals] is crossing the line. You can bring a dolphin into the world with bells and whistles, but if it dies afterwards, it makes no sense.' (P7)

Visitors raised awareness of the responsibility to take care of what exists, and what has been given birth too. For instance, also in another conversation between two visitors and the interviewer – about 'I wanna deliver a dolphin' – the possibility to improve animal welfare was imagined by the possibility of giving birth to pets:

> I: 'Would you like to deliver an animal? If you could have something in your belly.'
>
> R1: 'I don't know.'
>
> R3: 'I think people who own pets should have to give birth to them.'
>
> R1: 'Oh, such a good idea.'
>
> R3: 'This is a wild animal. We have so many animals that we have to take care of.'
>
> I: 'So if people want to have a dog they should first give birth to the dog.'
>
> R2: 'Instead of just buying them.'
>
> I: 'Why do you think this is a …?'
>
> R3: 'Because we somehow have taken responsibility for these creatures.' […]
>
> R1: 'It creates a bond.'
>
> R3: 'Yes exactly.'
>
> R1: 'And dependence. The whole species [of dogs] would then depend on our existence.' (P8)

Overall, most visitors considered ecology to be important, but whereas for some this meant that we should not interfere in animals' reproduction, others imagined that giving birth to endangered species would be a way of restoring an imbalance that the human species created or lead to a growing sense of animal care.

Furthermore, in order to articulate ecological care, reference was often made to overpopulation. For instance, as illustrated by this visitor articulating his view on ecology:

> 'It might be a terrible thing to say. But if everyone is born perfect and there are no more diseases, then yes, now overpopulation is already a problem. Disasters are also part of it.' (P9)

All in all, visitors asked what ecological care means in light of new reproductive possibilities. Does it mean not interfering in the reproduction of animals, focusing on a growing sense of animal care, actively arresting the decline of endangered species, or making sure that overpopulation is avoided?

The value of wonder. It was frequently emphasized that in striving for security and safety, we must ensure that we do not flatten out experiences. The value of the magic of the experience to bear and raise children was expressed by numerous parents, for example:

> '… with your hands on your belly, you feel an unbelievable emotion! I think we need this as a species, because it is not just about giving birth to a child, it also needs to develop into a human being. You must cherish that process. Humanity must. These are the people brought into the world that will soon have to take care of society.' (P7)

Often this experienced magic of pregnancy was linked to the reasoning that suffering also has a good side, in relation to necessity of a conscious experience that something is about to change when visitors talked about the importance of *'having to suffer a little'*. Experience and feelings of unpleasantness, pain and physical endurance were often considered essential in being alive. Some visitors reflected on the value of not knowing, the unexpected and the spontaneous. Others about the capability to be astonished; of a sense of the wonder of being in the world. Many visitors did not like the vision of a future in which reproduction would be fully controlled and *'just a matter of course'*. Visitors reflected on essential processes of life: the process of being pregnant, interdependent and getting older. Many visitors noted how the value of these processes lies in them being uncontrollable to some extent. For example, this visitor related family experiences to a desire not to use the 'Artificial womb':

> R2: My sister now has two daughters, but she was also pregnant with a boy, but she lost it. So, something like the artificial womb is super interesting, as you just said, then nothing can go wrong. Then everything can be checked properly.
>
> I: So, if you could choose?

> R2: I still choose the natural way I think. If it goes wrong I would regret choosing the natural way.
>
> I: But you want to take the risk?
>
> R2: But, it's also like it's supposed to happen, maybe this is just not what the future should? look like. (P10)

When speaking about reproductive technologies and the value of wonder, visitors often experienced contradictory feelings and opinions. One the one hand many visitors expressed amazement about the potential of current and emerging reproductive technologies. Tapping into this amazement fed the curiosity and desire to know *'what else is possible'*. On the other hand the fear that such experimentation would ultimately lead towards uniformity by trying to reach security, was also often expressed. As this visitor's comment illustrates:

> 'It is great if technologies work and for instance diseases can then be cured, but yes, [...] Our society is already inclined towards – we can make everything how we want it. I think that is the scariest thing, that you will one day miss all diversity.' (P11)

In conclusion, visitors point out the question how to develop reproductive technology that does not flatten out the experience of pregnancy and parenthood. Furthermore, they bring attention to the question of how to maintain our capacity for wonderment and of valuing diversity, while at the same time steering toward safety and convenience.

Discussion and conclusion

In this study, we mapped the responses of speculative design visitors who deliberated on the social and ethical implications of reproductive innovations. Taking a broad pragmatic view on morality and ethics, we found six recurrent moral themes of concern in developing reproductive technologies: the rights of the unborn; access and equality; social implications of individual choices; society as community; ecology; and the value of wonder. In this section we will compare our results to other studies that took a participatory approach, indicate on what issues this study opened-up the debate on reproductive technology, and reflect on speculative design as a tool for public engagement.

As mentioned in the introduction, other participatory studies have mostly examined attitudes towards reproductive technology from within a frame of technological innovation (Fauser et al., 2019; Goedeke et al., 2020; Hammarberg et al., 2017; Matar et al., 2019; Newson et al., 2019; Queiroz et al., 2020; Silva and Barros, 2012; van Kammen et al., 2006). In comparing our results to other studies that took a participatory approach we see that these reported on the first four themes as well. For example, the rights of children to access information about their oocyte donors (Newson et al., 2019), and the need for regulation of potential negative consequences for children who are born through stem-cell-based fertility treatment (Hendriks et al., 2017). Similarly, with regard to access and equality, other studies report on concerns regarding reproductive technology and age-based discrimination (Hodgetts et al., 2014; Iredale et al., 2006; Mosconi et al., 2018), or economic access (Hodgetts et al., 2014; Silva and Barros, 2012); as well as the potential to influence individuals (like BMI and smoking status) as part of reproductive treatment policy (Hodgetts et al., 2014). Matters concerning ecology and the value of wonder are missing from the participatory literature on reproductive technologies, yet these values were shown to be important in the reflections of visitors of the exhibition.

In the case of ecology concerns, it is not surprising that these are lacking in the literature. Because the technologies addressed in the exhibits that spurred such concerns - the 'Pig womb' and 'I want to deliver a dolphin'—are prohibited across the globe, many researchers don't consider deliberation about such issues relevant. However, as explained above, within our approach it is important to go beyond legal possibilities because when new technologies emerge our values and what we consider permissible will change and fluctuate accordingly.

The value of wonder is addressed within analytical bioethical literature, for instance in its debate on the 'naturalness argument'. This is an argument that in order to be moral, one must act in accordance with nature (Daston, 2014). It is described how historically the concept of 'nature' (as opposed to 'artificial') goes for objects that possess 'inner principles of change. […] changes that are unpredictable or incalculable for humans' (Schiemann, 2011, p. 105). One of the often-mentioned difficulties of the naturalness argument in the context of reproduction is that in public debates it can be easily used to privilege mixed-sex, and earlier, same-ethnicity, relationships and to justify discrimination against sexual and racialized minorities (Cole et al., 2012). Dichotomies opposing the artificial and the natural can lead to stereotyping and the creation of 'social monstrosities' within national political debates, and the exclusion of, for instance, lesbians and single women from access to assisted reproductive technologies in medical clinics (Bryld, 2001). However, this problem occurs in thinking of what is natural as being 'fixed', yet our results indicate that the argument to hold on to nature can also derive from the value of the wonder of autonomous change. It has been pointed out that even the most strongly upholders of the importance of 'naturalness' consider technological intervention justified under certain conditions (Kahane and Savulescu, 2012; Voultsos, 2017). These authors point out that it is not 'naturalness' but 'well-being' that is valued when the 'naturalness argument' is given. Our results indicate that when Reprodutopia visitors used arguments around 'naturalness', the characteristic of spontaneity, unpredictability and the well-being of society, is part of what is being valued.

Furthermore, imagination turned out to be vital in order for Reprodutopia visitors to envisage complex future realities and not solely depend on collective moral principles and reasoning. Our results show how the imaginative and emotional approach of deliberation facilitated value enquiry. Participants imagined a world and in articulating what it looked like they automatically stumbled upon different layers of life, thereby sharpening their reflections on what matters here and now. This importance of an imaginative and emotional approach to open up understandings of the ethical consequences of technologies is supported by the results of our previous study (Nabuurs et al., n.d.) as well as other participatory approaches using creative methods (Cox et al., 2009; Hudson, 2020; Mort et al., 2016). For instance, using theatre (Cox et al., 2009) and scenarios (Mort et al., 2016) these studies to report on opening up deliberation beyond technological risks and benefits to an articulation of a wide range of views on topics like ethics, trust, accountability, quality, governance and what kind of society is constructed in the deliberation of reproductive technologies. We would agree with Hudson (2020, p. 357), who used imaginaries to make sense of egg donation and found that:

> the imaginary is a valuable analytical device because it illuminates how ideas, ambivalences, deliberations and reflections about future family building are deeply social, embodied and reflexive. The imaginary advances sociological theorizing of reproduction more generally and helps to bridge existing tensions between individual practices and wider social and policy imaginaries.

In analysing visitors' inquiries, it became apparent that the contextual information expressed is vital to make sense of values and views. Visitors drew upon individual, cultural and material experiences to make sense of the speculative technologies

portrayed. On this account, it must be noted that the material experience visitors referred to is part of the designed objects. In our case, an animal ethics line of reasoning was prompted by the 'I wanna deliver a dolphin' and 'Pig womb'. Moreover, precisely because the future of reproduction was depicted as being driven by technology, the dichotomy between natural and artificial came to the fore and opened up the conversation on the value of natural pregnancy and wonder. These reflective mechanisms are described in more detail by Nabuurs (n.d.).

Lastly, throughout the research process, two important methodological reflections came up. First, the exhibition attracted a self-selective, culturally interested public limiting the diversity of moral reflections. Speculative design in general has been criticized for merely attending to certain (elitist) participant groups, and not to others (Martins and Oliveira, 2014). In order to include a wider variety of publics and designs, a participatory culture should be fostered by developing a multitude of speculative designs, approached with an interdisciplinary and critical stance (Martins, 2014, 2016; Stead, 2017). To open up the debate, one suggestion is to diversify the makers of speculation, either by selecting a more diverse set of designers or by including participants in the making process (Heidingsfelder et al., 2019; Schuijer et al., 2021; van der Weele and Driessen, 2013); and focus explicitly on engaging marginalized publics (Fraaije et al., 2022). Another way of reaching a broader public with speculative design is to use it in a focus group setting. This would allow the researcher more influence over the selection process, for example by holding focus groups at schools, community, and science centres or to organize sessions with both citizens and people working on the development of such reproductive technologies.

Second, Reprodutopia showed the potential of speculative design to build 'agonistic spaces', in which the desirability of certain visions and conflicting goals can be negotiated through debate (Björgvinsson et al., 2012, as cited in Heidingsfelder et al., 2019). As our results showed, visitors took different stances towards the same technologies even though they viewed the exhibits with the same value in mind. In incorporating speculative design in focus groups, the potential of the ambiguity of the objects to stimulate constructive conflict can be used to even better advantage.

In conclusion, getting back to the question of the added value of speculative design in opening up the discourse on reproductive technologies and social values, we found that Reprodutopia led to conversations on the social and ethical implications of reproductive innovations regarding six themes: the rights of the unborn; access and equality; social implications of individual choices; society as a community; ecology; and the value of wonder. Notably, issues concerning ecology and wonder are not usually described in the participatory literature on reproductive technologies. The imaginative and emotional approach facilitated bringing them to the forefront. Furthermore, Reprodutopia brought to the fore the drivers and complex values that underpin analytical arguments like that of 'naturalness'. It did so by depicting a technology-driven future. In order to broaden the range of reflections probed by speculative design both the makers and the audiences should become more diverse. If this is achieved, we see the potential for speculative design in the context of public deliberation about and in dialogue with R&I trajectories, as well as in contributing to the public capability of critically engaging with imagined futures.

Data availability

Not available for reasons of anonymity.

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Annex 1

Exhibit tags as visible in exhibition.

Exhibit name	Tag
I wanna deliver a dolphin	Would you like to have a child? And can you take the responsibility for another person's life? Do we need more humans on this crowded planet? Have you checked all options? Are you sure? How about a non-human child? Why don't you deliver an endangered species? Video: Ai Hasegawa (2013) Probability: very low [x] [] [] [] []
Lab romanticism	When you are an aspiring parent that has chosen in vitro fertilization (IVF) to conceive your child, you are going to be confronted with the realities of the fertility clinic. This reality, and the process you and others are about to undergo, are often perceived as sterile and detached. Lab Romanticism provides you with a new ritual that helps you reconnect to this process and turn it into a meaningful experience that can be shared with your partner. In this ritual, you are invited to be mindful of the last five days of the IVF process, in which the embryo 'travels' through five different stages before it's placed back into the uterus. Sexual intercourse might be replaced as a means to conceive a child, but that does not mean we have to give up on intimacy. Design: Lisa Mandemaker (2019) Probability: high [x] [x] [x] [x] []
Mono Parenting Kit	Imagine you take a sample of some skin cells and send them to a laboratory. Here, lab workers will re-programme your cells into both sperm and eggs using a process called in vitro gametogenesis. This technology enables you to have a child without a genetic partner, with a partner of the same sex, or even have a child with more than two parents. This technology might further distinguish between biological parenthood and types of parenthood based on social relations and child rearing and we might need a new language to express these different types. For example, having a child for which you provided 100% of the genetic material would make you a proud Zurent. Assembling a genetically identical child with a partner of the same sex, would make you both happy Mirents (assuming you both contributed 50% of genetic material).

Table (continued)

Exhibit name	Tag
	Design: Next Nature Network (2019) Probability: low [x] [x] [] [] []
Virgin Parent Ring	New reproductive technologies make way for new lifestyles and rituals to celebrate them. What if you are a devoted Catholic and the Virgin Mother is your greatest role model in life? Or you may have other reasons why you don't want to have sexual intercourse, but you do want to give birth to a child? One of your options would be to use in vitro gametogenesis (re-programming skin cells into sex cells) to become a mono parent. The Virgin Parent Ring would be for those future parents who are virgin and proud. Design: Next Nature Network (2019) Probability: low [x] [x] [] [] []
Reunion Network	What do the words 'relationship' and 'family' mean to you? Very probably something around the notions of 'trust', 'love' and 'care'. Are these concepts that we can design? The institution of marriage was designed long ago to secure family lineage and property, centuries before the concept of romantic love. New technologies, with decentralization at the core of their ideology (such as the Blockchain) enable us to reimagine the concept of family in new ways. ReUnion Network is a mobile application that helps people to organize bottom-up social support systems through long-term interpersonal care contracts. With this app, you can map out relations and actions. The first and most important action: establish a relationship with yourself. Design: Yin Aiwen, Genevieve Costello, Sarah Friend, Marjet Zwaans (2019) Probability: high [x] [x] [x] [x] []
Youterus	Would you carry your unborn child outside your body, but on your belly, like a kangaroo? Modern contraception separates sexual activity from pregnancy, and are widely used as a method of birth control in many countries. In the process of 'ectogenesis' (=birth outside the body of an organism), the body is disconnected from reproduction, which raises questions around the bonding between mother and child. Youterus enables the parent (Male, female, or other) to reconnect with the unborn child in a wearable artificial environment. Now, everybody is a mother! Design: Charlotte Marabito, Joana MacLean Probability: low [x] [x] [] [] []
Artificial Womb	The term 'Ectogenesis' (ecto = outside, genesis = birth) was coined by biologist J.B.S. Haldane in 1924; the first technical drawing of an artificial womb was patented 30 years later. In 2017, the world was in awe when an image of a baby lamb in an artificial womb circulated on the Internet. The premature animals grew fur and opened their eyes in what looked like a gigantic zip bag filled with liquid, attached to oxygen and nutrition systems. Some scientists claim that within ten years they could bring the first pregnancy outside the human body, creating the artificial circulation of oxygen, carbon dioxide and nutrients. At some point in your life, you might walk around with an artificial heart, lungs, or kidney. Scientists developed these some time ago. But what would an artificial womb look like and how will it change our concept of pregnancy, childbirth and gender? Design: Next Nature Network (2018) Probability: high [x] [x] [x] [] []
Pig Womb	What if animals and humans co-reproduced, like the bees and the flowers? Can you imagine an intelligent animal such as a pig being part of your family? The idea might sound slightly disturbing, but scientists have for decades already been carving the controversial path toward animal-to-human organ transplants. This is tissue engineering taken to its extremes: pigs supplying organic material to build artificial wombs. Design: Next Nature Network (2019) Probability: low [x] [] [] [] []

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Competing interests

The authors declare no competing interests.

Ethical approval

All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments. Because the data collection took place in the public domain, it did not pose risks to participants, and we did not include vulnerable individuals, no further evaluation is needed according to the self-check of the Research Ethics Review Committee of the Natural Science faculty of the University. This is in accordance with Dutch national guidelines. Any potential data obtained from children was not included in the analysis or write-up of the research.

Informed consent

After welcoming the visitors to the clinic and to the future, we would start the audio-recording and explain the purpose of the interview, how we would store (anonymised on a protected server), process (transcribe anonymously and analyse) and use the data (for one or two scientific publications). Subsequently, we would ask them to give oral consent, which would thus be audio-recorded.

Additional information

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