



The Artificial Womb: Speculative Design Meets the Sociotechnical History of Reproductive Labor

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In 2019, researchers from Máxima Medical Center in Eindhoven and scientists at the Eindhoven University of Technology, the Netherlands, received a €2.9 million grant from the EU-program Horizon 2020 to develop an artificial womb. By 2025, they will in all likelihood have developed a prototype. Announcing its development, an image of an artificial womb prototype went viral in more than 3 million online search results. The image of the prototype was taken during the acclaimed Dutch Design Week in 2018, where it was first presented as design-for-debate by Professor Guid Oei of the Máxima Medical Centre. Hendrik-Jan Grievink and Lisa Mandemaker, designers affiliated with the Dutch Amsterdam-based studio Next Nature Network, designed the prototype in collaboration with the Eindhoven team.

Next Nature Network also worked together with the team in Eindhoven to organize a design-fiction exhibition titled *Reproductopia* (2019). The

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exhibition, curated by Next Nature Network, opened in October 2019 at Droog Gallery in Amsterdam. By way of speculative design objects, *Reprodutopia* imagined future scenarios around the artificial womb that were meant to spark debates about the ways in which a fully functioning artificial womb may alter our attitude toward reproduction, relationships, and love in the twenty-first century.

In this chapter, I focus on the installation of the prototype of the artificial womb at *Reprodutopia*. I take its speculative design as entry point into an exploration of the cultural and medical histories braided around the future scenarios of the artificial womb. I will show that the speculative design of the artificial womb—including the accompanying design objects on display at *Reprodutopia*—echoes several past experiments and imaginations of women's bodies, notably pertaining to the uterus, as sites of ongoing socio-cultural and biological contestation.

Analyzing the prospects of the artificial womb—itsself already an interdisciplinary undertaking—in the setting of a futuristic speculative design exhibition, I aim to show that speculative art has greater leeway than academic writing to transgress limits, to max-out ideas, and to use imagination to let us experience and imagine things that do not yet exist or seem to be impossible. With this approach, I endorse trends in scholarship aimed at showing how stories and imaginaries are intrinsic to doing science (e.g., Jasanoff & Kim, 2009; McKittrick, 2021; Felt, 2014). Reproductive technologies have the potential to alter the meaning making by and behavior of their users profoundly, which calls for interdisciplinary involvement in reflecting on such impact through speculative design (Verbeek, 2006).

Speculative design itself, however, also deserves scrutiny, as it draws on, articulates, and materializes, as I will show, *particular* sociotechnical histories. Knowledge of such histories enables us to understand the direction of the speculative design under study. What I aim to make explicit in this chapter is what it takes in terms of interdisciplinary work to show the variety of histories involved. Although I will discuss one project that resulted from the interdisciplinary collaboration between artists and scientists, namely *Reprodutopia*, I need other forms of interdisciplinarity to analyze the messages implied in the speculative design of the exhibition.

Speculative Art and Emerging Reproductive Technologies

At first glance, design may seem to carry little weight in discussions on the future of reproduction technologies. Yet, as claimed by Marshall McLuhan (2003) in *Understanding Media: The Extensions of Man*, reflections on new technologies require an artistic eye: “The serious artist is the only person able to encounter technology with impunity, just because he [sic] is an expert aware of the changes in sense perception” (p. 31). Such a statement may have an overly romantic ring to it, and I do not agree with McLuhan’s idea that *only* artists can understand the days and ages we live in. However, as Oscar Wilde once famously wrote, “Life imitates Art far more than Art imitates Life” (Wilde, 1899, p.17). Artistic imaginaries play a vital role in the development of new technologies, and our ideas about emerging technologies are strongly influenced by the stories we tell.

Reflection on the possible impacts of emerging reproductive technologies and on the future embedding of these technologies in our societies involves a complex task. Scholars in science and technology studies (STS) have pointed out that professionals find it difficult to imagine unknown futures (Felt et al., 2009). Doing so requires that we make tangible and palpable what is usually intangible and impalpable. Yet, art practices can help us to do just that. Artists come equipped with a toolkit that can generate ways of relating to new technologies, showing a wider repertoire of responses—such as affective reasoning and embodied knowledge (Roeser et al., 2018; Cuhls & Daheim, 2017)—than those merely focused on quantifiable impacts, abstract reasoning, and the exchange of rational arguments.

Artworks, in fact, are sites of meaning through which ideas and stories about emerging technologies are organized, shaped, stretched, and circulated. Artistic representations of reproductive technologies—be it in film, literature, or speculative art practices—can show us how people relate to these technologies. Art practices contribute to the materialization of shared norms and values, while the future of reproduction and reproductive technologies has meanwhile occupied the mind of artists for

decades—think of Lilith in Octavia Butler’s novel *Dawn* (1987), the hatchery of Aldous Huxley’s novel *Brave New World* (1932), or the fetus fields of sci-fi movie *The Matrix* (Lana Wachowski and Lilly Wachowski, 1999). Art may thus help us to move beyond specific limits of our views and conceptualizations.

What speculative art and design add to the sciences are tools and resources to reflect on social norms and values, anxieties, expectations, and desires braided around emerging technologies. Anthony Dunne and Fiona Raby (2013), for example, describe their speculative exploration of future scenarios as a way of materializing critical thought to engage people in thinking about possible futures. Seen in this way, speculative design is a form of philosophy of technology that hails potential futures in the present to (re)think the social and cultural implications of emerging technologies. Speculative art practices, then, can be effective in questioning the set of narratives and subject positions triggered by developments in reproduction technologies. In Donna Haraway’s wonderful words: “It matters what matters we use to think other matters with; it matters what stories we tell to tell other stories with; it matters what knots knot knots, what thoughts think thoughts, what descriptions describe descriptions, what ties tie ties. It matters what stories make worlds, what worlds make stories” (2016a, p. 4). Speculative art and design can help us think ahead, in an attempt to anticipate unknown futures from different perspectives and positions.

Welcome to the Future Fertility Clinic

In Next Nature Network’s own rendering, as described on its website, *Reprodutopia*’s aim was to explore “the impact of technology on biological reproduction, gender and family” (Next Nature Network, 2019c). The exhibition

is disguised as a future clinic that presents thought-provoking visions of reproductive technologies by artists and designers ... It’s time for a much-needed discussion about the way technology radically alters our attitude towards reproduction, gender, relationships and love in the 21st century. If

we are to rewrite the human story, let's make sure it becomes a story that benefits all. (Next Nature Network, 2019c)

The words “future fertility clinic” evoke a sterile, brightly lit space with waiting rooms decorated with minimal design furniture and framed pictures on its walls of happy parents with their offspring. The exhibition space of *Reprodutopia* does much to reinforce this view. Entering the clinic, visitors are greeted by overly friendly employees, dressed in long white coats patched with corporate logos. These fertility officers walk you through the clinic and offer visitors overtly differential, personalized self-help-style advice for designing your prospective reproductive future with your partner(s).

Strolling around the future fertility clinic, it feels as if one has entered a site in between a high-end private medical facility and the Genius Bar at an Apple store. Using humor and exaggeration, *Reprodutopia* offers a variety of speculative design objects on the topic of artificial reproduction. Take, for example, the strap-on uterus that visitors can try on. This design piece resembles a wraparound baby sling (or belt). When wrapped around one's body with the straps tied, it supports the artificial womb from a carer's body. The idea is that in the future, parents and caretakers can freely share the carrying of the portable artificial womb.

To be sure, the prototype exhibited at *Reprodutopia* will not be used to help grow premature babies. The forthcoming Eindhoven prototype will be closer to a so-called biobag container. It will surround an extremely premature baby with fluids and delivers oxygen and nutrients through an artificial placenta that connects to the baby's umbilical cord. This yet-to-be-developed prototype will provide premature babies with an environment that simulates physiological conditions, to mitigate the often-chronic health issues premature babies are likely to suffer from in their lives. Due to a combination of organ immaturity and iatrogenic injuries, extreme prematurity is the leading cause of neonatal mortality and morbidity. In the US alone, over one-third of all infant deaths and one-half of cerebral palsy cases are attributed to prematurity (Partridge et al., 2017). Extending gestation artificially could, so is the expectation, reduce the risk of mortality, disability, and chronic illness associated with extreme premature birth. Scientists working in this field consider birthing

a deadly affair as well. As the surrogacy researcher Lewis writes, “hundreds of thousands of humans die because of their pregnancies every year” (2019, p. 1). In the US, about 1000 people die during childbirth and another 65,000 come dangerously close to dying. Unsurprisingly, safer gestation has always been the privilege of the white and wealthy. The medical hope is that developments in the artificialization of reproduction could lower the deadly risks of pregnancy and birthing, as well as prevent miscarriages and maternal mortality.

Anticipating the Future

Speculative art and design efforts comprise future visions, grounded in a shared present, that enable us to (re)imagine social realities, offering insights into how the world might be, or be made differently, in the future (Mann, 2018). The mandate of speculative design can be to spark debate and, in the case of *Reprodutopia*, to imagine future sociotechnical scenarios to raise questions about the interrelated ethical issues and social consequences as we can conceive them today.

The centerpiece of *Reprodutopia* was Next Nature Network’s artificial womb prototype, the one presented during the Dutch Design Week in 2018 by Professor Oei, one of the lead medical scientists of the Máxima Medical Centre in Eindhoven. The prototype, which filled an entire exhibition room to the brim, consisted of a collection of five synthetic air-filled spheres, the size of office ball-chairs, suspended from the ceiling. In the adjoining exhibition room, one entered the reproductive clinic. Upon entering, visitors were immediately accosted by one of the employers of the clinic eager to show them the items for sale.

It seems that the future of medical fertility clinics is fertile ground for merchandise and commerce-driven ritualization, as evidenced by the *Virgin Parent Ring* (Next Nature Network, 2019b) and *Lab Romanticism* (Next Nature Network, 2019a), two design pieces in the exhibition. In theory, artificial reproduction would allow for immaculate conception—virgins could grow a child in the artificial womb, like a present-day Mother Mary and Joseph. This possibility inspired the design of the *Virgin Parent Ring*. The two rings, which have the words “virgin parent”

engraved on their outside, will be available for purchase at the future clinic and may be exchanged between two parents. *Lab Romanticism*, in turn, has been designed to provide prospective parents with a selection of mindful romantic rituals to give some color and heart to the “detached” medical procedure of artificial reproduction and the sterility of the future reproduction clinic.

Like the *Virgin Parent Ring*, it “updates” long-standing, semi-religious, ritualistic, and romantic practices. Tasks include lighting candles, raking sand in a mini Zen garden, and exchanging rings, to offer future parents a semblance of romance. Through these two design pieces, *Reprodutopia* appeared to allude to the perpetuation and pervasion of commodification and marketization into the future artificial reproduction clinic, as well as to the persistent conservatism of the romantic imperative and coupledness.

Fertility and reproduction, as we all know, have co-determined the position of women since the fifteenth century. The carrying and birthing of children have been biologically assigned to women. Within capitalist, heteronormative, and patriarchal cultures, childcare and child-rearing have historically been imposed on women as unwaged labor. And the uneven division of labor in gestation, birthing, and parental care continues to be an important factor in the imbalance of the sexes.

Therefore, the development of this potentially disruptive humanoid organ obviously evokes important questions and horizons regarding the interrelations between reproduction, gender, and parenting. What are the affordances of reproduction without pregnancy and birthing? What might change between the sexes through artificial reproduction? What are the possible implications of the separation of sex and reproduction? Who reproduces, with whom (if anyone), and who takes care of the child? What might change in gendered parenting roles? Could this innovation lead to reproductive parity? And who benefits from these futures?

The *Parenting Kit* (2018), another Next Nature Network design, tacitly touches on the possibility of multiple-parent reproduction. Its design resembles a hybrid of an online DNA test-set and Microsoft software package. The description urges visitors to imagine a future in which anyone of us could send off a skin sample to a futuristic lab, and, through a process called “in vitro gametogenesis,” have these skin cells transformed

into both sperm and eggs. In this way, it would become possible to fertilize ourselves and create a baby on our own. The *Parenting Kit* enables us to have a child without a genetic partner, with a partner of the same sex, or to have a child with a group of individuals who together contribute 100% of the genetic material required for in vitro gametogenesis. The *Kit*, the description text concedes, allows for different forms of parenthood to emerge and be fostered. In the future fertility clinic, parenthood is available in Mono, Duo, and Poly versions. The *Kit* will further enable tinkering with and assembling a curated cocktail of genetic material to gestate offspring in the artificial womb. Here, *Reprodutopia* tacitly touches on the possibility of multiple-parent reproduction, a subject hardly discussed in academic scholarship in relation to reproductive technologies and artificial reproduction.

Echoes of the Past in Speculative Future Visions

Stories we *do* tell about the future of reproduction—whether imagined in the form of design-fiction, narrativized in science-fiction, or represented in films—are situated and embedded. They have histories, be it cultural histories, histories of science, technology and medicine, or histories of ideas, to mention just a few options. It is not at all self-evident, however, which of these histories are relevant for a critical analysis of what speculative design performs. Speculative design may be a form of philosophy of technology, while showing on which histories it draws will depend on the analyst's literacy in historical accounts and the analyst's conceptual ability to identify specific similarities with or particular absences in past practices. Below, I will present the similarities and absences *I* noticed.

The first thing that struck me when observing the prototype exhibited at *Reprodutopia* is that the bunch of air-filled, flesh-colored balls look eerily like loitering testicles. It is of importance—and tragicomic—that the prototype has more likeness to dangling testicles than to the shape of, say, a womb. The “absence” of the *form* of the womb in this setting testifies

of a long history of power relations at stake in artificial womb research and design. The lead medical scientists of the incubator-cum-artificial-womb project at Eindhoven are an all-male cast. Mentioning their sex is noteworthy here. The development of an artificial womb consists of situated and embodied acts. “Situated knowledges,” a term coined by Haraway in 1988, describes the interrelated and inseparable planes of ontology, epistemology, politics, and ethics. All knowledges, Haraway argued, are situated knowledges. Science is a doing, and this doing is done by bodies. Bodies are marked, and their marking is always determined by their role in “scientific and technological, late-industrial, militarized, racist, and male-dominant societies” (Haraway, 1988, p. 581). By implication, then, the development of the artificial womb, as embodied and situated acts of knowledges, is inevitably overburdened by existing power relations.

The second thing I noticed is that the artificial womb in Eindhoven represents steps in the increasing artificialization of biological reproduction. Its nomen, “artificial womb,” has breathed new life into the age-old vision of the growth of a human embryo outside the body—ectogenesis, from the Greek “ecto,” outer, and “genesis,” birth. The hanging spheres evoke images of the alchemical homunculus—the mother of all innovations: artificially created life. And not without reason. The aspiration to design an artificial womb, or a womb replica if you like, is an age-old dream in the history of medical science. Its history can be traced back to early automata when medieval alchemists huddled around glass containers trying to conjure up miniature men in tiny bottles. Some medieval alchemists liked to believe that a homunculus could have superior powers, if not become a morally and spiritually better version of the human. Speculative future visions of reproductive technology hark back to these earlier fantasy visions of the homunculus.

There are, of course, different interpretations of the story of the homunculus and how it relates to the development of the artificial womb. One may argue that the homunculus actually represented the erasure of women from sexual reproduction by technology: men creating beings without female involvement. The same can be said to apply to the artificial womb. One may argue that the prospect of artificial reproduction will liberate women from the health risks involved in carrying and birthing

babies, re-assign agency to women, free them from the constraints of their bodies and so-called biological clocks, and fundamentally change the labor relations and gender divisions in society. Others may argue that although the artificial womb is likely to open possibilities for non-normative forms of parenting, while also mitigating health risks associated with prematurity, gestation, and birthing, large-scale adoption of such womb might as well exacerbate socio-economic inequalities if access to artificial reproduction is not equally distributed. In this respect, Shulamith Firestone, a leading feminist thinker and major proponent of artificial womb technology, wrote in *The Dialectic of Sex* (1970) that “[i]n the hands of the present society there is no doubt that the machine could be used—is being used—to intensify the apparatus of repression and to increase established powers” (p. 193). Firestone actually feared that artificial reproduction could be used to repress women when conditions of gender inequality would remain unchanged in society.

The yet-to-be-developed artificial womb is to function as a new type of “incubator,” another similarity I identified, meant to intervene in the high number of premature baby deaths every year. Jeffrey P. Baker’s *The Machine in the Nursery* (1996) offers a case study of the development of the incubator from its origins in the Paris maternity hospital between the years 1880 and 1922. In the early days of the incubator, in late 1870s and early 1880s in France, its design was purported to be analogous to the womb: a closed system containing warm fluids and impenetrable to light. In an attempt to lower maternal and infant mortality and premature infants, the French pediatricians Stéphane Tarnier modeled the first infant-warming machine, the *couveuse*, after the chicken incubator. The machine bolstered a nationwide campaign against infant mortality. The device was meant to help mothers and nurses, not to replace them, according to Baker. Moved to the US, the incubator underwent a radical transformation. Baker describes how American pediatricians collaborated with various third parties, such as professional inventors and entrepreneurial physician-inventors (Baker, 1996, p. 67). The American incubator resulting from these collaborations was labeled an “artificial womb” and was meant to replace mothers and nurses (p. 70).

Claire Horn explains in *Psyche* that attempts to create an artificial womb were accompanied by the shared concern of male obstetricians,

doctors, and scientists “that mothers themselves, with their [assumed] unsanitary practices, irresponsible behavior and anxious fussing, might pose a danger to their infants—a danger that could be curbed by placing the uterus-incubator firmly in the doctors’ hands” (2020). The current developments in the prototyping of an artificial womb by a team of researchers in Eindhoven can be understood in terms of this medical history of the incubator. Although the artificial womb is developed to lower the risks of extreme prematurity—the leading cause of neonatal mortality and morbidity—the incubator was developed in part because American doctors and scientists thought that the number of premature infants and the level of neonatal mortality could be reduced by separating women from their babies.

Future visions of the artificial womb thus mirror broader social values, systems, and histories. Take, for example, the seemingly convenient and benign portable womb-sling exhibited at *Reprodutopia*, allowing expectant parents to share the weight of carrying the fetus. This sling needs to be situated in the broader history of the uterus as a site of capitalist labor exploitation. The uterus underlies a major historical shift in Western societies. In her seminal book, *Caliban and the Witch: Women, The Body and Primitive Accumulation* (2004), Silvia Federici exhaustively documents how control over the uterus was critical to the foundation of capitalism. Key drivers of the development of capitalism in Europe were colonization, the Atlantic slave trade, the expropriation of the European peasantry from its lands, and the repressive control of women’s bodies, including unwaged and reproductive work. Federici documents how the primary accumulation of capital implied the development of a new sexual division of labor subjugating women’s labor and women’s reproductive function to the production of the workforce. She presents the rise of capitalist labor in Europe as a development that fundamentally undermined the position of women in society. According to Federici, creating surplus value in capitalist economies became possible only because of the forced labor of enslaved workers, and the unpaid housework and reproductive labor of women confined to the domestic sphere and excluded from waged work. Forced and unpaid labor, including unpaid reproductive labor, created and sustained the conditions for the production of value, she argues. Such labor fueled the construction of a

new patriarchal order, based on women's subordination to men. Finally, and crucially, it also resulted in the mechanization of women's bodies as machines for the production of new workers, which included the criminalization of abortion, and the decriminalization of rape of proletarian women. Federici describes the various ways in which a concerted effort was made on the part of the church and the state to undermine class solidarity and divide the emerging working class along gender lines. Women, Federici argues, were to produce labor-power for the farms and workshops and cannon fodder for the imperial wars.

Conclusion

To this day, for too many women, fertility and motherhood mean risking their bodies, their careers, and sometimes even their lives, while being constantly scrutinized, judged. The cultural theorist Valeria Graziano makes a poignant argument, on Facebook in 2018, about motherhood that is worth quoting at length:

For too many women, motherhood is not a choice as they are pressured into it as the only social role available to them. For too many women, motherhood is a choice, yes, but of giving up on other practices, studying, working, creating, participating in politics or in the life of their communities, simply because the joys of motherhood are all they are supposed to aspire to while they toil away in the solitary drudgery of domestic labour. For too many women, motherhood can only take the form of sacrificial love, as they exhaust themselves juggling the demands of making a living, of complying with bureaucracy, of confronting the devastating paucity of care provisions. For too many women, because of the demands of making a living, of complying with bureaucracy, and the devastating paucity of care provisions, motherhood is not an option at all.

My critical analysis of *Reprodutopia* shows that its view of motherhood is not speculative enough. It basically involves, as revealed by my interdisciplinary identification of historical similarities and contemporary absences, the projection of the present onto the future, which tethers the future of

motherhood to ongoing gendered parenting roles in a neoliberal market as well as a patriarchal culture. If we continue to cling to gendered social formations and neoliberal economic structures, however, this will frustrate the development of alternative futures and different knowledge hierarchies.

In principle, speculative design can foster a critical re-orientation that does neither entirely abandon the historical formations and economic structures of motherhood and gendered parenting roles, nor give in to those structures and formations as a necessary limit on what comes next (Mann, 2018). Going forward, we need more *and* more radically speculative design, as well as more artistic and science-fiction imaginaries of the socio-political and economic futures of reproductive technologies, including their possible implications. We need to feed the public imagination with possible other maternal futures, in an attempt to find “still possible, recuperating pasts, presents and futures” (Haraway, 2016b).

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