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# Prenatal Imaging: Egg Freezing, Embryo Selection and the Visual Politics of Reproductive Time

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## Abstract

In the last decade, two influential new reproductive technologies have been introduced that are changing the face of *in vitro* fertilization (IVF): egg freezing for "fertility preservation" and time-lapse embryo imaging for embryo selection. With these technologies emerge alternative visual representations of the assisted reproductive process and its relation to time. First, frozen egg photographs provide a lens onto contemporary reconfigurations of reproductive aging and stage a life-death dyad between the frozen cell and the embodied self, which drives treatment rationales for egg freezing. Second, time-lapse embryo imaging creates visual recordings of developing embryos in the incubator; the resultant quantified visual information can then be repurposed as a tool for predicting embryo viability. As these two sets of prenatal images reference dying eggs and non-viable embryos, they demonstrate a necropolitics of reproductive time, in which not only the generativity of new life but also the encounter with the death, finitude and fallibility of reproductive substances drives a widespread and intensified engagement with reproductive technologies.

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## Introduction

In the second half of the twentieth century, prenatal life became visually recognisable in the grey flurries of fetal ultrasound, the stylized photography of fetal remains and the iconic scene of fertilization by micro-injection of a sperm into an egg cell.[1] Prenatal images play a key role in shaping reproductive experiences such as pregnancy or *in vitro* fertilization (IVF) and have gained symbolic significance as they circulate beyond the clinic into advertisements, political campaigns and popular culture at large (Franklin, 1993). Feminist scholarship as well as science and technology studies (STS) have drawn attention to the importance of reproductive imaging in the cultural imagination of the reproductive process. Technologies such as ultrasound and fetal photography have all been highly significant not only in visualizing prenatal life, but in reconceptualizing the reproductive process itself, the gendered bodies involved in this process and the temporal structures that govern them (Duden, 1993b; Franklin, 2014; Petchesky, 1987).

Now, in the first two decades of the twenty-first century, two influential new reproductive technologies have emerged that offer alternative representations of the assisted reproductive process and its relation to time. Firstly, egg freezing, the popular "fertility preservation" technology, produces photomicrographs of frozen eggs that reference a period of ongoing cryopreservation. Secondly, "time-lapse embryo imaging," an IVF embryo screening technology, relies on the visual analysis of the developing embryos in the incubator. Both egg freezing and time-lapse embryo imaging are recent, and rapidly-adopted, innovations in assisted reproduction that engage cellular time by instrumentalizing, respectively, the temporal plasticity and developmental regularity of prenatal life.

The visual mediations of cellular life that these technologies produce bring the extracorporeal reproductive process into view. Although the assisted reproductive process has ceased to be located

exclusively inside the female body since the advent of IVF four decades ago, the recent popularization of egg freezing for fertility preservation and time-lapse embryo imaging for embryo selection has routinized the visualization of an originary *ex vivo* component of the individual reproductive process.[2] Beyond "*in vitro* fertilisation (IVF), the *in vitro* cryopreservation of eggs and the *in vitro* incubation of embryos have become the subject of representation and reproductive decision-making.

Through the analysis of US and UK case studies of photomicrography[3] of frozen eggs and time-lapse videos of developing embryos, I will make the case that these twenty-first-century visual mediations of early, extracorporealized prenatal life reconfigure the reproductive process in line with shifting treatment rationales that underlie an ongoing expansion of IVF and its industries. I do so through a cultural analysis[4] of these new reproductive images, which hitherto remained hidden from the intended parent but are now routinely shared.

The first case study revolves around the photomicrographs of frozen eggs. Egg freezing has become a widely influential reproductive technology in the last decade. An increasing number of fertility clinics offer the procedure and the possibility of freezing eggs has been widely covered in public debates, popular culture and academic literature (Carroll & Kroløkke, 2018; Jackson, 2017; Van de Wiel, 2014a). Now that frozen eggs may continue to exist for extended periods of time outside the body, cellular photography of ova becomes a means for relating to them while they remain in the freezer. With a close reading of the frozen egg's photomicrograph, I will analyse how the discursive practices and apparatuses of imaging that frame the frozen eggs reconceptualize and repoliticize reproductive time in cells and bodies alike.

Time-lapse embryo imaging, the second case study, attracted national media attention when it was introduced in the UK in 2013 and has been heavily promoted by fertility clinics in Britain and across the globe as an alternative, and more advanced, form of embryo selection. Time-lapse embryo imaging systems integrate incubators and cameras to create time-lapse videos of developing embryos. These systems can

observe and record temporal developmental markers (e.g., the timing of cell division), which provide the basis for a predictive viability assessment of the embryos. Time-lapse embryo imaging is rapidly being adopted in fertility clinics around the world and is changing clinical and research practices. Emerging in the wake of an increasingly public visual interface with prenatal life, the visualization of cellular development in time-lapse embryo videos adds yet another visual dimension to the encounter with early human life on screen. Time-lapse imaging also introduces a novel instrumentalization of cellular time, given that temporal markers — rather than static morphology — of embryo development become the basis for selection.

Both of these imaging technologies introduce new, individualized representations of prenatal development which provide a foundation for reimagining the reproductive process and the temporalities that govern it. By visualizing frozen eggs and developing embryos in the context of the fertility clinic, these imaging technologies bring the *ex vivo* component of the assisted reproductive process into view. Once outside the body, the time of cellular stasis or cellular development can align with patients' reproductive goals of extending fertility or predicting viability. In turn, the suggested possibilities of cryopreserving fertility and assessing embryo viability harness reproductive futures to expand the indications for fertility treatment in contemporary IVF. First, egg freezing can expand the group of potential IVF patients as an infertility treatment for the fertile population to avoid future infertility. Second, time-lapse embryo imaging expands IVF by adding extra treatment options for each treatment cycle to avoid future failed implantations. The future-oriented treatment logics underlying this expansive drive can be analysed through a close reading of the visual mediations of eggs and embryos that co-emerge with the rising popularity of egg freezing for fertility preservation and time-lapse embryo imaging for embryo selection. This paper, then, explores the entanglements of embodied, technological, cellular and capital temporalities in twenty-first-century visual cultures of assisted reproduction to analyse the treatment rationales underlying the expansion

of contemporary IVF.

## Freezing Eggs, Freezing Time

In the last decade, egg freezing has become an increasingly popular reproductive technology for women who would like to have the possibility of having genetically-related children later on in life. Particularly the use of egg freezing to circumvent age-related infertility has received widespread attention both within the fertility sector and in wider public discourses (Inhorn, 2017; Jackson, 2017). As what is effectively an IVF procedure with a period of cryostorage between egg extraction and fertilization, egg freezing introduces an alternative temporal organization of the reproductive process. Instead of the conventional nine months, the duration between ovulation and a potential birth may be stretched, while the act of extracting and freezing eggs itself can be framed as a first step in an IVF cycle that may lead to future live births (Van de Wiel, 2014b). Yet what makes egg freezing a unique reproductive technology is that it does not seek to create a "take-home baby" in the first instance but is instead organized around the continuation of reproductive potentiality, or fertility.[5] The resultant cryopreserved fertility is more temporally flexible; it is frequently framed as "extended fertility" (Mohapatra, 2014) and shifts existing temporal limits to childbearing and conception.

With the temporal plasticity of freezable eggs — and the reproductivity and fertility associated with them — emerges a new temporal politics of reproduction. Scholars of reproduction have situated egg freezing within broader conflicting societal pressures on women's life course management. In *Making Parents,* US sociologist Charis Thompson (2005) highlights challenges of synchronization between different bureaucratic, cyclical, social and biological time scales of the fertility clinic, in which the temporal structures of the working day, the menstrual cycle, cellular developmental rhythms and age norms pertaining to childbearing meet (pp. 111–112). Following Thompson, Australian sociologist Catherine Waldby (2015) suggests that women use egg

freezing to reconcile the "otherwise incommensurable differences between the time scale of their reproductive biology, the steadily elongating nature of the life course and the increasingly iterative structure of portfolio careers and relationship formation" (p. 479). Several feminist scholars, such as Cattapan, Hammond, Haw and Tarasoff (2014), have argued that egg freezing is an expensive and risky procedure that provides an individualist solution to structural social issues that result in later childbearing (p. 239). These include labor-related provisions of parental leave and childcare as well as class-specific patterns in relationship formation (Carbone & Cahn, 2013; Inhorn, 2017).

In responding to external social pressures on women, the growing popularity of egg freezing also reflects the production of new temporal regimes that govern the management of embodied female reproductivity throughout the life course. When presumably fertile women can pre-emptively undergo infertility treatment, the biomedicalization of infertility begins to extend to the fertile life course.[6] Conversely, egg freezing is also often framed as a means of mitigating the "biological clock" (Wyndham, Figueira, & Patrizio, 2012) and thereby suggests that fertility can be extended to the infertile life course. Through this double movement, cryopreservation enables the overlapping of fertile and infertile life courses in new ways, resulting in a state of what we may refer to as "postfertility." This is not to say that the categories of fertility and infertility have become obsolete — quite the contrary. Rather, these categories are mobilized in new ways and begin to signify through one another when infertility is lived in the fertile life phase and fertility is positioned as extending beyond pre-existing reproductive age limits.

As a consequence, fertility becomes an increasingly uncertain, and precarious, referent. As both fertility and infertility become indications for treatment to, respectively, preserve or achieve reproduction, egg freezing poses new questions about the agency that may be exerted over timing reproduction. Combined, the possibility of egg freezing simultaneously produces the suggestion of increased agency and increased uncertainty about the ongoingness of reproductive potential.[7] In a context of a rapidly

expanding fertility sector — projected to grow to $21 billion worldwide by 2020 (Maida, 2016) — egg freezing presents new opportunities for creating consumer need pertaining both to making fertility legible and exerting agency over its relation to time.

As the possibility of egg freezing becomes the occasion for interpellating large groups of presumably fertile women to consider "extending fertility," it becomes necessary to reflect critically on the entanglement of cultural and clinical processes that reconceptualize reproductive time in the production of treatment rationales for this new reproductive technology. One cultural-clinical object in which these processes coalesce is the visual representation of the frozen egg, which provides a case study for reflecting on the reproductive futures, pasts and presents that animate influential treatment rationales for egg freezing. The frozen egg image follows a rich history of reproductive imaging in which both the visualization of prenatal life — in ultrasound, in IVF, in fetal photography — and the temporal logic it represents have been adopted to rationalize and politicize the reproductive process. Perhaps the most influential example of this is the use of ultrasound imaging technology and fetal photography in anti-abortion rhetoric, which appealed specifically to fetal developmental time to limit access to abortion.[8] Much as the visible fetus was ascribed autonomy and independence, so scientific images of gametes (sperm and eggs) play a key role in contemporary imaginations of reproduction that position gametes as autonomous protagonists in an origin story of disembodied cellular fusion (Lie, 2012; 2015). Given the temporal plasticity of cells that can be stopped and started at will in tissue culture (Landecker, 2007), the recognition of the cellularity of the human reproductive process suggests that it, too, can be temporally manipulated through techniques of cryopreservation. The iconic image that epitomizes human agency vis-à-vis reproductive cells is the fertilization of an egg in IVF, which, as US social scientist Sarah Franklin (2013) demonstrates in *Biological Relatives,* has been instrumental in shifting popular understandings of the reproductive process (p. 249).

By focusing on the photomicrography of frozen eggs in particular, we can examine the temporal dimension of the visual politics of reproductive time in the context of egg freezing. I will analyse how the image of the cryopreserved egg expresses divergent constructions of temporality in the cell and in the reproductive body of the "self," which in turn animate influential treatment rationales that align with new modes of biomedicalizing female reproductivity and fertility. In doing so, I draw attention to both the specificity of the photographic medium and the object depicted in the image in order to highlight their significance for the reframing of reproductive time in egg freezing practices.

One new type of prenatal imagery emerging with this reproductive technology is the photograph of the frozen egg. Women who freeze their eggs may receive photographic images of the cells they have cryopreserved after their procedure. On her blog about her "egg freezing process," a woman using the online alias "Eggfreezer" includes one such picture. She decided to freeze her eggs to, in her own words, "beat my biological clock, [and] have kids even when my reproductive system would have it some other way" (Eggfreezer, 2008a). Her blog documents her experience of the procedure over the course of several months on the Blogspot platform. She concluded her account of the egg freezing process with a post that included a picture of her frozen egg and the following text:

> Here is an actual egg from my retrieval …. This egg was inside me (in a premature state) for 32 years — even before I took my own first breath as a newborn. Had I not had the retrieval, this egg would have just never developed and died off last month— just another one of the many millions that die off over a woman's lifetime. Instead, through modern medicine, it was able to be matured and extracted and it is now quite literally frozen in time alongside 27 others, potentially to be the starting building block of a future human being …. This is the tie — the everything and anything that is what a woman prefers when she wants "her own" biological baby. Whatever it is that she wants — what I want — it's

> in there. Part of me is in there. (Eggfreezer, 2008b)

More than a diagnostic image, or a souvenir of the procedure, the photograph of the frozen egg that is "now quite literally frozen in time" functions as a reference point for Eggfreezer to consolidate her conceptualization of both the cryopreserved cell and her embodied self. When Eggfreezer uses the image of the frozen egg to conceptualize her reproductivity, the image becomes a form of what US art historian Amelia Jones calls "self-imaging: the rendering of the self in and through technologies of representation" (2006, p. xvii). Rather than reflecting the self's appearance, the egg photograph presents a cellular temporality which allows a rendering of the self in relation to time.

Regarding the temporal dynamics of self-imaging, Jones theorises "self-portrait photography as a technology of embodiment" that stages an engagement with "the fact of the aging and inevitable death of the subject" (Jones, 2002, p. 972). She reasons that

> The photograph is a sign of the passing of time, of the fact that what we see in the shiny surface of the photographic print no longer exists as we see it: it is a sign, again, of our inexorable mortality as well as, paradoxically, an always failed means of resecuring our hope of having the photographed subject "live forever." (2006, p. 46)

Jones reads the photograph's "frozen time" as a sign of passing time: it is a visual confrontation between the photographed moment that "no longer is" and the moment currently inhabited by the viewer. The resultant temporal distance between the past depicted in the photograph and the present moment of observation, she suggests, becomes an extendable principle that includes a future in which we will have changed, in which we — and those depicted — will fail to live forever. In this reading of the photograph as not simply an image of the past, but as a temporal relation that incorporates the past and the present while extending into the future, photography marks a confrontation with finitude.

Jones develops her argument in dialog with Peggy Phelan's (1997) *Mourning Sex*, which argues that the still image of the photograph

"serves both to 'conjure' the moment, the scene in which the photograph was taken, and to take the moment out of time, [...] to give it a new temporal logic" (p. 157). The significance of this new temporal relation between the frozen image and the living subject, Jones argues, follows from the use of photography as a "technology of embodiment." Jones contends that the subject performs "herself or himself within the purview of an apparatus of perspectival looking that freezes the body *as* representation and so — as absence, as always already dead — in intimate relation to lack and loss" (2002, p. 949). In this way, photography functions as a technology of embodiment that points to the finitude of the living, embodied subject.[9]

Jones develops her thought following French theorist Roland Barthes's reflection on mourning and photography in *Camera Lucida.* Occupied with the death of his mother, Barthes (1981) writes: "In front of the photograph of my mother as a child, I tell myself: she is going to die: I shudder … over a catastrophe which has already occurred. Whether or not the subject is already dead, every photograph is this catastrophe" (p. 96). The photograph's catastrophe follows from its "anterior future": the image presents a past moment that tells of a future that has already passed at the time of viewing (Barthes, 1981, p. 96). In its resistance to releasing the moment into the past, the photograph "induces belief that it is alive … but by shifting this reality to the past ('this-has-been'), the photograph suggests that it is already dead" (Barthes, 1981, p. 79). The catastrophe thus lies in the "arrest of aliveness, which simultaneously foreshadows the terminal arrest of death"; the photograph captures the tension between the two temporalities of aliveness and arrest (Yusoff, 2007, p. 222).

The photograph of the egg is poised at the tension between aliveness and arrest. The egg in this photograph is framed as an element of a redistributed reproductive embodiment that Eggfreezer recognises as "part of me," even if it is stored in the freezer. Jones's approach to photography as a "technology of embodiment," in which multiple temporalities meet, speaks directly to Eggfreezer's use of the egg's

photograph to imagine the temporal relations between the cell, its reproductive potential and her embodied self.

Time is at the forefront of this photograph, which depicts an egg that has been extracted because of its vulnerability to the passage of time and is now reframed as "literally frozen in time" (Eggfreezer, 2008b). This framing suggests that the photograph's "frozen moment" here does not primarily reference the slippage of a moment of the embryological examination of the extracted cell in the past (Barthes's "this-has-been"), but rather signifies the frozen state of the egg characterized by the arrested cellular time in the present ("this-is"). As the frozen moment of the photograph depicts the frozen state of the egg, this photograph presents an alternative temporal logic to the photographs theorized by Barthes and Jones. Rather than a "sign of the passing of time" that is a "failed means … of having the photographed subject 'live forever'" (Jones, 2006, p. 46), the photograph references a cell whose existence in time is seen to be halted and may thereby maintain its viability. The frozen egg "induces belief that it is alive" without "shifting this reality to the past" (Barthes, 1981, p. 79); the cell's arrested time thereby does not foreshadow death but is framed as having a futural orientation that promises both its own latent aliveness and its future reproductive potential. The photograph of the egg thus becomes a sign of an *ex vivo* reproductivity that is not subject to the passage of time; this circumventing of reproductive finitude through cryopreservation is at the heart of the promise of egg freezing practices.

Given that the image depicts the arrested present rather than the past moment, while the egg is frozen, the photograph is "live" — in a sense analogous to the "live" broadcast of moving images and in keeping with the latent life recognized in the frozen egg. The photograph is not "live" in the sense of simultaneous recording and broadcasting, but rather it is live because the photographic trace of the past depicts a "this is," or a "still now," in which the time of observation matches the time of cryopreservation while the egg remains in the freezer. As a counterpart of the finitude associated with the passage of time both in the body and in

the photograph, this state of being "literally frozen in time" becomes an affirmation of continued reproductivity.

While the egg's image affirms the aliveness of arrested time, in the confrontation with this image Eggfreezer directs the work of mourning mortality to the site of the body: "Had I not had the retrieval, this egg would have just never developed and died off last month" (Eggfreezer, 2008b). A reversal of Barthes's anterior future, the image of the *in vitro* cryopreserved egg signifies its aliveness in the present while Eggfreezer invokes an *in vivo* past of the egg in which it is "going to die" and would have been "already dead" at the time of writing (Barthes, 1981, p. 96). With the cryopreserved egg functioning as a foil for her body, Eggfreezer suggests the female body becomes the site of the incessant dying of "many millions" of eggs "over a woman's lifetime" in a process that culminates in the finitude of age-related infertility. In this model, the salvaging of eggs and their preservation in the freezer rescues them from the aging body "through modern medicine" (Eggfreezer, 2008b).

However, there is no particular reason to assume that this specific egg would have "died off last month" if she had not "had the retrieval." The egg may have stayed with her for several more years; it could have ovulated in the future; there is even a slight possibility that this very egg could have been fertilized *in vivo* without medical intervention. Rather than a medical fact, the invoked imminent death of the photographed egg is a narrative device that stages a charged life-death dyad between the frozen cell and the embodied self, which drives the rationale for egg freezing.

As Sarah Franklin and Celia Roberts (2006) observe in *Born and Made*, the notion that the egg was saved "through modern medicine" is a trope so familiar that it is expressed in the term *assisted* reproductive technologies. In Eggfreezer's case, it is not assistance with reproducing at present, but rather assistance with shifting reproductive time that egg freezing affords. Landecker observes that "the ability to freeze, halt or suspend life" as "an infrastructural element of contemporary biotechnology" results in a situation in which "to be biological, alive,

cellular, also means (at present) to be a potential 'age chimaera,' to be suspendable, interruptible, storable, freezable in parts" (2007, p. 228). Eggfreezer's account presents a negotiation with the implications of becoming freezable in parts. With reference to the photograph of the frozen egg, Eggfreezer positions the egg as the locus of a continued reproductivity "frozen in time," analogous to the way in which the photographed moment is congealed in time. However, in this move, the visualization of the alternative temporal logic of the egg's continued existence functions as a technology of embodiment that positions the female reproductive body as the site of finitude. As a consequence, paradoxically, through the temporal specificity of the imaging process that references the continuity of "latent life," it is the mortality and finitude of the body that become increasingly visible (Radin, 2013).[10]

The process of egg freezing, then, produces prenatal images that mediate reproductive time in new ways. The temporal specificity of the photograph of the egg affirms the notion that Eggfreezer can "beat [her] biological clock" and freeze reproductive time, much like the image freezes the time of the photographed moment. The temporal distance between the depicted moment and the moment of observation, in turn, reinforces the finitude of embodied fertility. The frozen egg's photograph thus aligns with a treatment rationale that motivates egg freezing through this dynamic between a suggestion of technologically mediated agency and embodied loss related to reproductive aging.

This visual reframing of reproductive time in egg freezing practices thus results in a life-death dyad in which the cell continues living, while the self from whom it was taken becomes the locus of mortality. This points to an implicit necropolitics of reproduction, in which the temporalextension of reproductive potential afforded in the egg freezing procedure, and its recognition in the image of the frozen egg, hinges upon the construction of embodied reproductive loss and *in vivo* egg death. The politics of the popular emphasis on egg death follows from the privileging of the foil of future infertility over concerns about the biomedicalization of female fertility, pre-emptive overtreatment, physical

and financial risk, reification of a gendered reproductive imperative and the dependencies produced through the reframing of reproductive potential as requiring ongoing monitoring, treatment and capital investment. The spectre of preventable finitude characterizes a broader "shift from current reactive treatments … to the proactive management of lifelong reproductive potential" exemplified not only in egg freezing but similarly in new processes of embryo selection (Beim et al., 2017).

## Time-lapse Embryo Imaging

Whereas egg freezing is a technology for *extending* the reproductive process and prolonging the time of fertility by slowing down cellular time to cryopreserved stasis, time-lapse embryo imaging is a technology for *speeding up* the reproductive process and shortening the time to so-called "IVF success" by selecting the "best" embryo on the basis of its temporal development. Hailed by some as the most significant development in IVF in decades (Walsh, 2013), time-lapse embryo imaging is a novel technology for embryo selection that uses visual analysis to assess embryo viability. Since 2013, it has been widely promoted in the UK and global sales of the major time-lapse device manufacturer have increased with each quarter (Vitrolife, 2017). In IVF procedures, embryos develop in incubators for three to five days after fertilization before being implanted. Embryologists traditionally remove the embryos from the incubator on a daily basis to check their development under the microscope and decide which embryos to transfer to the woman's body. In time-lapse embryo imaging systems, the embryos remain in the incubator for the entire incubation period and are instead photographed every five to twenty minutes. These images are collated and accelerated in time-lapse videos that show fertilized eggs splitting into two cells, shaking like liquid bubbles, and dividing into a compact embryonic cell mass.

By comparing the observable characteristics of an incubated cohort of embryos — such as the timing of cell divisions — to historical

embryo populations that have resulted in live births, time-lapse embryo systems are used to predict which embryos will be "viable" or "non-viable." In spite of a Cochrane review suggesting that the current evidence of increased live birth rates is too limited to justify the routine adoption of this technology (Armstrong et al., 2015), time-lapse imaging systems have been rapidly introduced in fertility clinics across the globe.[12] Notwithstanding the efficacy of this method, its particular entanglement of imaging and reproductive processes reframes the figure of the observable, viable embryo through the distribution and rhetorical framing of time-lapse videos.

At first sight, time-lapse embryo imaging does not seem to be a novel technology at all. Contemporary developmental biology uses several more advanced and detailed time-based visual technologies for studying embryos than time-lapse embryo imaging. For example, laser scanning microscopy (LSM) and light sheet fluorescence microscopy (LSFM) allow *in vivo* 3D imaging of living embryos at cellular resolution, thereby offering greater visual detail than the light microscopy technology used in time-lapse systems. Reflecting the objective of creating "*in toto*" representations of embryogenesis, these imaging methods enable continuous, automated individual cell tracking throughout the entire early embryo –without the temporal gaps characteristic of time-lapse imaging (Tomer et al., 2012; Wellmann, 2017).

Time-lapse films of embryos, by contrast, have been produced and circulated for over a century. Historians of science have analysed the significance of biological time-lapse imaging primarily at a time when cinema emerged as a new time-based medium (Landecker, 2012; Olszynko-Gryn & Ellis, 2017). Not only is time-lapse imagery of embryos no longer novel, but film scholar David Lavery even wrote an article on the "disappointing career of time-lapse photography" and dismissed this visual technique as "mundane" and "commonplace," suggesting that time-lapse videos of dividing cells have lost their "otherworldliness" (Gaycken, 2012, p. 62; Lavery, 2006, p. 2, p. 7). Likewise, German historian of science Janina Wellmann argues that the early association

between the moving image and the suggestion of liveliness is no longer convincing, given the prevalence of animation in contemporary visual culture (Wellmann, 2017; see also Landecker, 2012).[13]

Nevertheless, time-lapse embryo imaging represents a significant innovation in twenty-first-century IVF; with its rapid and widespread introduction emerges a new set of prenatal images and a retemporalization of the reproductive process in which the time of development, capital, labor and representation meet in new ways. First, in the context of the fertility clinic, the familiar embryo video gains importance as at once a diagnostic image, an individualized recording of patients' potential future children and an origin story that starts in the incubator rather than the maternal body. It depicts an image of developmental time that becomes meaningful in an anticipated reproductive continuum implicated in the notion of "IVF success."

Second, it represents a move from static to dynamic imagery in embryological practice. By automating embryo assessment, the time-lapse medium thus allows a reorganization of the relation between the time of embryo development and the temporal organization of embryological practice. Third, it is not just a representation of early embryo development, but itself a novel tool for selection.[14] Beyond the observation of embryos in the incubator, time-lapse embryo imaging has a data-driven component. As the time-lapse system's camera records the embryos, the visual information is quantified and analysed with algorithms to predict the developmental potential of each embryo. Now a selection method, the developmental time of embryo development comes to relate to the time of value production through treatment rationales that biomedicalize the reproductive process in new ways and expand the scope of IVF.

The option of adding this newly visible step in the IVF cycle requires additional clinical and financial decision-making on the part of the patient. Time-lapse embryo imaging is one of the few laboratory technologies that is directly marketed to patients (Pottage, 2018). For example, unlike most embryological equipment, Eeva (early embryo

viability assessment) has a dedicated website, which targets intended parents and promotes time-lapse embryo imaging as a means to approach "IVF with a higher level of confidence" (Auxogyn, 2017). As part of its direct-to-consumer marketing strategy, the website includes a patient testimonial video titled "Courtnay and Michael's Journey," which introduces the time-lapse apparatus, the embryo videos it produces, rationales for treatment and exemplary patient responses to them (The Eeva Test, 2015b).

The testimonial video tells the story of a couple who had spent a long time trying to conceive and eventually decided to undergo IVF. The video opens with a smiling Courtnay, who tells the viewer about the time she missed a call from her fertility doctor, who contacted her sooner than she had anticipated. From the very first sentence, Eeva is framed as the enabling condition for a successful pregnancy that emerges sooner than you would expect — in this case soon enough to miss your doctor's phone call. The success of IVF is here temporalized: Courtney, who had long attempted to conceive, found a way to speed up the process and become pregnant quickly with the assistance of the Eeva technology. Upon returning the call, the doctor announced Courtnay's pregnancy by asking: "You know the news, right?" When Courtnay tells us how she responded by asking "what news are you talking about?", the camera zooms out and we see her partner Michael rocking a baby, affirming the outcome of the pregnancy that the doctor announced on the phone. Linking the moment of the doctor's announcement that Courtnay recalled and the diegetic present in which the baby is recorded, the video establishes a link between the clinically and technologically mediated experience of embryo selection and a "take-home baby." In doing so, it makes a visual argument for an investment into the technoscientific management of this early stage, which here plays a decisive role in establishing "IVF success" and was instrumental in speeding up the reproductive process by avoiding implanting embryos that are not predicted to lead to a viable pregnancy.

The video's next scene suggests extracorporealization is

instrumental to this speeding up of the reproductive process. It cuts to a still image of a green hilly landscape with a white heterosexual couple holding hands, walking down a sand path. The woman holds a string leading to a large embryo floating above her head. Resembling a helium balloon, a red multi-cellular embryo hangs in the air, enclosed by a three-dimensional green square that looks like the rectangular containers holding the embryos in the Eeva incubator. The floating embryo resembles a thought-balloon, signifying how the embryo is almost umbilically connected to the intended mother's mind rather than her body. In keeping with Franklin's argument that reproductive technologies are often framed as "offering nature a helping hand," the Eeva green logo visually resonates with the scene's natural surroundings and is presented as guiding the couple on the path of their "IVF journey" (Franklin, 2013). The peaceful scene paints a picture of a mode of reproduction in which the apparatus exists in harmony with nature and the intended parents, while the embryo exists outside the maternal body on the road to "IVF success."

As counterpart to this visual image, the time-lapse embryo imaging system is itself framed as a more transparent alternative to the maternal body.[15] In a televised BBC news report about time-lapse embryo imaging, Dr. Simon Fishel is quoted as describing the technology as "almost like having the embryo in the womb with a camera on them [sic]" (Walsh, 2013). The idea of the machine as an alternative, technocultural "womb" that emulates the body through enhanced visibility is also a further extension of the pervasive ideal of bodily transparency in Western medicine. Dutch media scholar José van Dijck (2005) explores the history of this ideal in *The Transparent Body* by analyzing various medical imaging technologies as "the material embodiment of collective desires and fantasies" (pp. 15–17). The visualization of live embryo development in time-lapse videos affirms the association between increased visibility and medical progress that Van Dijck describes. They moreover fulfil a dual diagnostic and affective function, analogous to ultrasound images, as visualizations of the first encounter with prenatal life, which is now

moved forward to the time before implantation (2001, pp. 108–9).[16] The time-lapse embryo videos likewise become meaningful as an extension of what Barbara Duden (1993b) describes as "the desire to remove the frontier between the viewer's eye and the unborn" and to witness "the breakdown of a horizon which, since the beginning of history, had made the unborn an unseen and unverifiable presence" (p. 566). By extension, while the time-lapse apparatus facilitates a mode of reproduction in which the embryos are distant from the intended mother's body, the concomitant increased visibility of the embryos may function to mediate this distance by positioning the visual — rather than embodiment — as the key mode of accessing the desired potential future child.

As US science scholar Hannah Landecker (2006) has argued for early biological cinema, which allowed people other than scientists to "participate visually in the sights of scientific work" (p. 123), so does time-lapse embryo imaging provide a means to share images of the embryos that previously would stay within the embryological lab. The scientific films that Landecker describes opened up the scientific gaze to other participants; here time-lapse embryo imaging allows patients to partake in the embryological gaze. Time-lapse imaging manufacturers highlight the possibility of improving patient communication with this shared vision as one of the key selling points of this technology (Vitrolife, 2015). In turn, fertility clinics present the inclusion of a "special download" with the time-lapse embryo imaging add-on as a perk to (potential) patients (CAREfertility, 2018). The testimonial video also shows the smiling couple watching their "special-download" video of the embryo that developed into their son at home. In a differently cut version of the patient testimonial, Courtnay's voice-over reads embryo incubation as the originary development moment: "When you watch the video of the Eeva test, we were astonished that really everyone starts out that way and that we got to see a picture of our son at a cell level" (The Eeva Test, 2015a). Thus framed as depicting embryonic individuals, time-lapse embryo videos run the risk of reproducing the maternal erasure and ascription of personhood to prenatal life which was widely criticized and politicized in

fetal ultrasound, while positioning IVF as a model for conceptualizing the *in vivo* reproductive process (Franklin, 2013; Petchesky, 1987; Stabile, 1992).

In sharing the clinical gaze in this way, the seemingly objective imagery of developing embryos also visualizes a specific, and contested, treatment rationale that suggest that the IVF process can be sped up by adopting an automated, predictive, data-driven method of selecting embryos. Accompanying the visual of two developing embryos, the voice-over explains that "your IVF team uses the Eeva test results with their traditional grading methods to select the best embryo for transfer." In the testimonial video, we see two embryos developing next to a text box that explains that the time-lapse technology "analyses the developmental potential of the embryos and categorizes them into 'High' and 'Low.'" After a couple of divisions, the words HIGH and LOW are superimposed on the two embryos, which subsequently move to a screen where two embryologists of "your IVF team" interact with them. Rather than handling the embryos and controlling conditions, the embryologists' monitoring of the incubated embryos thus becomes a matter of watching the screen and analyzing statistical and visual data. This screen-based, digital approach to embryo selection, which visualizes the developmental differences between embryos, promotes the notion that there is a universal regularity in the timing of embryo development that can be both observed and instrumentalized to predict viability by means of automated standardization, quantification and predictive analytics.

The temporal regularity of embryonic cell divisions has been recorded for over a century (Cohen, 2013). The understanding of embryogenesis as subject to a temporal law of development was recognized as early as 1800 by thinkers like the German critic Karl Philipp Moritz, who conceptualized embryo development as organized by "rhythmical time," or the recognition of an interlinked timed repetition and variation (Wellmann, 2015, pp. 30–31). In nineteenth-century embryology, this scientific attention to the regularity of time-based phenomena was

produced through sequential representations arranged into "*Normaltafeln*," or the assortment of "thousands of individual moments in thousands of individuals built into an ascending temporal series of static moments" (Hopwood, 2000; Landecker, 2006, p. 126). After what Mexican-American historian of science Jimena Canales called the "cinematographic turn," the late-nineteenth-century representations of biological processes became "visible *as* processes" through the time-based medium of film (Canales, 2002; Wellmann, 2011, pp. 310–313). The key aspect of scientific cinematography is of course the representation of time, which could now be manipulated to give visual access to phenomena that were previously too slow or too fast to observe. The temporality of cinematography becomes meaningful and valuable at the conjunction of "the time of experiment, the time of recording and the time of demonstration" (Landecker, 2006, p. 123; Wellmann, 2011, p. 314).

After the turn of the millennium, time-lapse embryo imaging introduced a "cinematographic turn" in the IVF clinic. The technology's synchronization of the different modes of clinical, recorded and playback time that Landecker references not only introduce a lively, accelerated representation of the developing embryos. The integration of an additional mode of what we may call "datafied time" renders the timing of cellular divisions into a tool for selection. The quantified visual information deduced from the developing embryos is key to both the assessment of their viability and the provision of data for the development of algorithmic tools to assess similar embryo cohorts in the future. Through this datafied approach, incubated embryos are viewed in light of historical embryo populations to predict their viability.

Another variation of "the biological" functioning as a tool in contemporary reproductive biomedicine (Franklin, 2013), the characterization of the embryos' temporal regularities as a method for selection — as distinct from natural phenomena — is relevant because this has made them patentable under US and European law. Although controversial and contested by both the research and bioethics communities (Cohen, 2013; Sterckx, Cockbain, & Pennings, 2014), the EU

and US patent offices have issued patents that cover the precise timing of embryo development, including clauses that specify a "time interval … between the resolution of cytokinesis 1 and the onset of cytokinesis 2 [of] 8-15 hours" — thereby explicitly aligning developmental time with capital time.[17] Here the extracorporealized embryo is no longer only located *in vitro*. Rather, the embryo becomes *in silico*: both as digitalized image, which may be shared between medical professionals and intended parents, and as data sets and patentable algorithmic tools for selection, which emerge from data circulations between clinics and manufacturers. The cinematographic turn in IVF thus has a distinctly data-driven character that bridges past, present and future.

In conclusion, time-lapse embryo imaging videos, characterized by the speeding up of photographed time to produce moving images that show an accelerated version of the recorded reproductive process, make a visual argument for embryo selection. The wiggling embryos dividing their cells are emblematic of "the need to animate, enliven, set into motion as an expression of our desire for … 'feeling alive'" (Zarzycka & Papenburg, 2014, p. 166); the embryos' movement conveys both a current liveliness as well as the possibility of future life in the proclamation of "HIGH" viability. While presented as diagnostic and quantitative measurements, the time-lapse embryo videos also visualize a culturally significant origin story that positions the beginning of identifiable human life outside of the maternal body, and inside the benevolent technology. After extracorporealization, the incubated embryos become visually accessible to intended parents, who may now see what was previously confined to the embryologist's gaze. The reliance on an algorithmic analysis of the visualized embryos speaks to an increasing importance of large data sets and predictive analytics in assisted reproduction. The rapid introduction and distribution of time-lapse embryo imaging expresses an expansive drive within contemporary assisted reproduction. Whereas egg freezing expanded the group of potential candidates for treatment by making not only infertility but fertility an indication for IVF, time-lapse embryo imaging expands the IVF treatment steps as well as

patients' and clinics' investments in the instrumentalization and visualization of the reproductive time of embryonic development.

## Conclusion

In keeping with the focus of *Catalyst's* special section, both the reproduction of imaging processes and the imaging of reproductive processes are key in appreciating the new reproductive decisions that intended parents navigate in twenty-first-century assisted reproduction. By analyzing the rhetorical framing of frozen egg photography and embryo development videos, I have drawn attention to the way in which the visual representation, acceleration and congealment of reproductive time can align with a particular treatment logic. What is at stake in the introduction of these treatment rationales is a broadening indication for IVF — whether through enlisting a group of fertile women as candidates for pre-emptive infertility treatment or through expanding the IVF cycle with additional treatment options.

In this process, the two new reproductive technologies of egg freezing and time-lapse embryo imaging are not only changing the face of IVF but also retemporalizing the reproductive process.[18] Egg freezing *slows down* the reproductive process by introducing a period of cryopreservation between egg extraction and fertilization. The concomitant temporal extension of the reproductive potential counterbalances ongoing embodied fertility decline. The frozen egg's photograph reframes a familiar picture of a gamete into a reproductive image poised at the distinct temporalities of frozen and embodied time emerging with egg freezing. Unlike conventional photography, the depicted frozen moment did not signify an irrecoverable flash from the past, but an ongoing state of cellular cryopreservation. The resonance of frozen time in the still image and the cryopreserved cell affirmed the "liveness" of both. In so doing, this presentation of cryopreserved time reinforced the contrasting finitude of the aging body, its precarious fertility and the loss of its eggs. The rhetorical framing of this reproductive

image aligns with a treatment rationale that motivates egg freezing through a dynamic between the affective attachment of anxiety and loss to embodied female reproductive aging and the ascription of potential viability to the imaged, un-aging egg frozen in time.

Conversely, time-lapse embryo imaging is framed as a technology to *speed up* the reproductive process by implanting the most viable embryo first. Time-lapse embryo imaging uses timed observation to instrumentalize the temporal regularities of prenatal development in embryo selection. Time-lapse embryo imaging, characterized by moving images that show an accelerated version of the recorded reproductive process, likewise affirms a treatment rationale for embryo selection. The system visualizes both the animation of early life and the drama of selection by superimposing a "HIGH" and "LOW" assessment of their viability. While the patient testimonial video showed the baby resulting from this process, the charge of the clinical embryo videos follows from the proximity of continued and failed viability in the petri dish.

As these two sets of prenatal images reference non-viable embryos and dying eggs, they demonstrate a *necropolitics of reproduction*, in which not only the generativity of new life, but also the increased awareness of the death, finitude and fallibility of reproductive substances drives the engagement with reproductive technologies. These life-death dyads — whether between the frozen and embodied egg or the viable and non-viable embryo — propel new, future-oriented treatment rationales for broadening the indication for IVF. The fragility of these vital distinctions becomes apparent in Eggfreezer's framing of her frozen egg as a promise of continued liveliness that provides the "building block" for a "future child" and is also "part of [her]" (Eggfreezer, 2008b). The tenuousness of this promise emerges in her final blog post: "ALL THE VITRIFIED EGGS DIED ON THAW." Seven years after freezing, the attempted thaw renders the photograph into an image of mourning after all, and she writes: "This is unfathomable. I cannot begin to explain the grief I am feeling. I have a call with Dr. B on Monday morning." Despite her commenters urging for an update in the years following, we never

hear from her again.

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## Notes

[1] The use of diagnostic medical ultrasound in obstetrics and gynaecology was introduced in the 1960s and quickly became a routinized part of pregnancy care. It is rooted in a history of measuring distance using sound. As early as 1794, Lazzaro Spallanzi demonstrated that bats navigate through the dark using echo reflection from high frequency sound. This technique was automated in the late 19$^{th}$ century and subsequently used primarily in maritime underwater navigation. Early medical use of ultrasound focused on its purported therapeutic effects and later the diagnosis of tumors, before there was a global boom in research and clinical use of fetal ultrasound in the 1960s (Newman & Rozycki, 1998; Woo, 2002). Fetal photography was first popularized in Nilsson's 1965 photo essay "The Drama of Life Before Birth" in *LIFE Magazine*. The stylized photography of fetal remains was a ground-breaking depiction of prenatal life that has become part of "the mental universe of our time" (Duden, 1993a, p. 14). The visualization of *in vitro* fertilization (IVF), and particularly the visual representation of a needle inserting a single sperm into the egg in intracytoplasmic sperm injection (ICSI), has become ubiquitous as a stock image of human reproduction (Franklin, 2013, pp. 246-50).

[2] *Ex vivo* (outside the body) is the counterpart of *in vivo* (inside the body). *In vitro* (eg. *in vitro* fertilization) is a technical term for "in glass."

[3] Photomicrography refers to photographs taken with the aid of a microscope. This is to be distinguished from microphotography, which produces photographs that are shrunk to very small scale and require a microscope for viewing (Peres, 2007, p. 94).

[4] This article follows the practice of "Cultural Analysis" as developed by Mieke Bal (1999). In this approach, the analyst purposively does not apply a single method to understand an object, but rather brings diverse analytic and theoretical lenses in dialogue with particular case studies and cultural objects (Bal, 2002, p. 4).

[5] The phrase "take home baby" is commonly used both in research and clinical settings to refer to a live birth as a result of an IVF cycle (Peters et al., 2007). This phrase may be distinguished from other measures of reproductive success, such as clinical pregnancy rates, that do not necessarily result in a live birth (Chetkowski, 2014). Clinical pregnancies can result in spontaneous abortions, ectopic pregnancies, foetal deaths and neonatal deaths (within 28 days of birth) and such cases may be excluded from a 'take home baby' rate (Peters et al., 2007, p. 127).

[6] I use "biomedicalization" in line with US science scholars Mamo et al.'s (2003) definition: "Biomedicalization describes the increasingly complex, multisited, multidirectional processes of medicalization, both extended and reconstituted through the new social forms of highly technoscientific biomedicine. The historical shift from medicalization to biomedicalization is one from control over biomedical phenomena to transformations of them" (p. 161).

[7] See Taussig et al. (2013) on critiques of potential and potentiality in biomedicine, especially pp. 54-55 on the politics of embryonic potential.

[8] It was the popularization of fetal imaging, Ros Petchesky argues in her classical studies on the visual cultures of reproduction, that was instrumental in the rhetorical shift from religious claims about the beginning of life to a medical discourse of biological facts about prenatal development which were reified through fetal imagery (Petchesky, 1987, 1990). Following Petchesky, Sarah Franklin analyses the temporal politics of anti-abortion activism and argues that the 1980s right-to-life movement harnessed a biological discourse that emphasized "biological development rather than divine authority" and thereby embeds the "religious time of theo-ontology within the secular time of biology" (Franklin, 2014, p. 112).

[9] Like Jones and Phelan, Mary Ann Doane holds that "the privileged form of the index has been associated with death," thereby invoking a notion of finitude to theorise the medium-specificity of the photograph (Doane, 2007, p. 129).

[10] As Radin argues was the case for genomics, these cryotechnologies, which harness latency in assisted reproduction, give momentum to the "anticipatory regime[s]" that animate egg freezing discourses (Radin, 2013, p. 500; Van de Wiel, 2014b, p. 4).

[11] Necropolitics can be read as the counterpart of biopolitics, which references not the governance of life but the governance of death and dying. Whereas Achille Mbembe positions biopolitical investment of power into life against the necropolitical investment of power into death, Rosi Braidotti theorises the relationality between a biopolitics and necropolitics (Braidotti, 2013; Mbembe, 2003; van der Zaag, 2016). I here use the term to refer to the politics of the recognition and legibility of death, finitude and fallibility in the management of reproduction. Beyond a politics of bringing life into being, contemporary reproductive management, I argue, discursively produces loci of death and decline that function as sites of individualized and politicized governance.

[12] As an indication, the Swedish company Vitrolife, one the of two major suppliers of time-lapse embryo imaging equipment, reported a significant growth in sales between the end of 2014 and 2016, from 30 million to 160 million SEK (Vitrolife, 2016). Time-lapse imaging is a treatment option in the majority of large fertility clinics in the United Kingdom.

[13] Myers and Dumit (2011), by contrast, argue that cellular time-lapse images can "seem to impart too much life" through the suggestion that they show not only motion but also intention and personification in cellular processes (p. 254).

[14] See Franklin (2013) for a discussion of the embryo as tool.

[15] Referencing the origin story recounted in Genesis 1-3, the Eeva system's name suggests a correspondence to the biblical name Eve, meaning "mother of all the living" (Gen 3:20 Revised Standard Version). This is a telling association, given that the secular creation story told through the time-lapse embryo videos shifts the locus of life's origin by staging a first visible encounter with prenatal life while it is enclosed by the machine rather than the mother.

[16] The suggested continuity between the time-lapse embryo video and fetal ultrasound — and, by extension, the embryo and the fetus — becomes explicit in a promotional video of time-lapse embryo imaging by the largest UK fertility chain, CARE Fertility. Titled *Jaycie's Journey Using*

*Embryoscope Time Lapse Imaging at CARE Fertility*, it shows a succession of a single embryo in a time-lapse video, a traditional two-dimensional ultrasound video, a three-dimensional ultrasound video, and postnatal footage of a baby girl named Jaycie (CARE Fertility, 2015).

[17] See patents US7963906 B2, 2011, US8337387 B2, 2012, EP2430454 B1, 2013.

[18] This retemporalization is in keeping with Landecker's argument that "being a cellular entity after cryobiology means being freezable and open to artificial synchronization; any living thing, after these interventions, becomes an object that can be stopped and started, suspended and accelerated" (Landecker, 2007, p. 232). The temporal plasticity of cells in tissue culture directly comes to bear on reproductive timing in the case of egg freezing.

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