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Role of science fiction in conceptualising the reproductive future: a linguistic and literary perspective

 Alexandra Krendel ¹, Mike Ryder ²

¹Languages, Cultures and Linguistics, University of Southampton Faculty of Arts and Humanities, Southampton, UK

²Marketing, Lancaster University Management School, Lancaster, UK

Correspondence to

Dr Mike Ryder;
m.ryder@lancaster.ac.uk

Received 10 December 2024

Accepted 22 February 2025

ABSTRACT

In this paper, we explore how members of the public invoke science fiction tropes and references in response to the topic of complete ectogenesis (where the entire development of a fetus takes place outside of the human body in an artificial womb environment) and, to a lesser extent, genome editing. This paper addresses a critical research gap as fiction is central to how the public make sense of new technologies. This research is timely, as human clinical trials of artificial placenta and womb technology are expected to start within the next few years. We argue that gauging public opinion on this technology is a critical early step in understanding how the public might respond to such new technologies, should they become available in the near future and be presented in a particular fashion.

Using corpus linguistic techniques, we analysed a large dataset of 15 548 YouTube comments (382 057 words) made in response to a video that depicts a fictional artificial womb facility, which went viral in December 2022 when some viewers believed it to be real. We identified several statistically significant trends, as commenters associated the video with science fiction, horror and dystopian fiction, while also making specific reference to *Aldous Huxley*, *Brave New World* and *Star Wars* (Clone Wars). These observations reveal how popular science fiction narratives serve as a key point of reference and that they stand as a powerful warning in the public imagination, and as a potential barrier to public acceptance of new reproductive technologies—despite the potential benefits for social justice and reproductive rights. Our findings therefore have implications for how scientific developments are communicated to the general public.

INTRODUCTION

In this paper, we explore how members of the public invoke science fiction tropes and references in response to the topic of complete ectogenesis, where the entire development of a fetus takes place outside of the human body in an artificial womb environment. To a lesser extent, we also consider the role of gene editing and how these two technologies may be combined. To do this, we analysed a large dataset of >15 000 YouTube comments made in response to a video that depicts a fictional artificial womb facility called EctoLife (Al-Ghaili 2022). Specifically, we used corpus linguistic approaches to investigate literary references within the comments, thus combining the empiricism and statistically driven language analysis tools of linguistics with

a literary perspective that gives insight into the specific texts that video commenters refer to, and how they relate to current debates within the field of science fiction.

This is important because human clinical trials of artificial placenta and womb technology are expected to begin within the next few years (Hunter 2024). Therefore, gauging public opinion on this technology is a critical early step in understanding how the public might respond to such new technologies, should they become available in the near future. However, it should be noted that the findings of this study particularly pertain to one specific representation of complete ectogenesis technology and so may not be generalisable to all representations of such technology. Nevertheless, these findings have implications for how new reproductive technologies should be communicated to the public once they are realised.

For this research, we conducted a linguistic analysis of literary references because the past literature identifies such references as central to how the public make sense of new technologies (Cave *et al* 2019). It is also notable that much of the existing academic literature on complete ectogenesis often references literature as well—specifically Aldous Huxley's science fiction novel *Brave New World* (Chan 2009; Kendal 2018; So *et al* 2022). Fiction (including both literary and filmic works) can be useful for making sense of complex bioethical issues, but science fiction in particular can negatively impact perceptions of these issues 'if it turns the public against science that would otherwise produce benefits in terms of human well-being' (Chan 2009, 399), as is the case for ectogenesis technology.

However, research on how science fictional tropes shape public perception of novel technologies is rare. Indeed, Cave *et al* (2019, 335) argue that more work is needed in this area to 'explore whether such fictional representations are influencing a broader segment of the public, and if so, whether they are doing so in ways that could be considered distorting or extreme'. This article conducts such an exploration with a view to assisting science communicators who wish to advocate the use of ectogenesis technology for emancipatory purposes in the future.

Ectogenesis technology has the potential to be extremely important from a social justice perspective, by promoting social equality between those who have the physical capability to gestate and are socially conditioned to do so, and those who do not



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To cite: Krendel A, Ryder M. *Med Humanit* Epub ahead of print: [please include Day Month Year]. doi:10.1136/medhum-2024-013207

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have this capability or this pressure (Firestone 1970). Indeed, ectogenesis has the potential to destabilise current norms around who is responsible for child-rearing (Cavaliere 2020). As Kendal notes, complete ectogenesis would have the effect of:

promoting sexual equality in reproductive endeavours, providing for women who do not have a functional uterus..., creating gestational alternatives for women expected to experience high-risk pregnancies (including transplant patients and those undergoing chemotherapy), and providing options for women who for social reasons do not wish to be pregnant (including those whose careers would be adversely affected by pregnancy, such as models and elite athletes). (2017, 185–186)

This being said, others have identified that complete ectogenesis technology has the potential to increase social inequality. For instance, Horn (2021) argues that it could lead to the curtailing of abortion rights, as a fetus could be moved to an artificial womb in situations where the fetus would otherwise be terminated.

While Cavaliere (2020, 78–79) notes that the emancipatory potential of ectogenesis is inherently limited by existing social structures (eg, equal access to ectogenesis for all being a practical challenge), it is, however, undoubtable that other reproductive technologies such as in vitro fertilisation have had some positive social justice implications despite this not being financially accessible to all. These include enabling lesbian, gay, bisexual, transgender and queer (or questioning) people to conceive and enabling pregnancy later in life, and ectogenesis could also enable these positive outcomes (Kendal 2017).

As such, we consider the following questions:

1. What genre references are made by YouTube commenters when they refer to EctoLife, and what tropes are salient to these references?
2. What references do they make to specific works of fiction when they refer to EctoLife, and which aspects of these works are highlighted?
3. What do the video comments tell us about how YouTube viewers react to EctoLife and how they engage with fictional depictions of the reproductive future?

In the next section, we give an overview of the EctoLife video to provide context for the methodology and analysis that follows.

DATA SELECTION

The EctoLife video was selected for this study because of its widespread popularity and the extent to which it captured the attention of its viewers. When it was first uploaded in December 2022, this video went viral online as it was widely interpreted as depicting real-world technology (see Reuters Fact Check 2022). This is partly because the only textual indication that EctoLife is not real comes in the final 15 s of the video, when the words ‘concept by: Hashem Al-Ghaili’ appear on the screen, and even this can be interpreted ambiguously as it is unclear whether the EctoLife facility has been realised in the real world.

The creator of the video, Hashem Al-Ghaili, labels himself as a science communicator and his Facebook and YouTube profiles, where he shares science communication content, have approximately 33 million and 971 000 followers respectively at the time of writing (10 December 2024). When approached by fact-checking organisations, Al-Ghaili claimed after the video went viral that ‘the main goal of creating the video was to ignite the discussion about an emerging technology and to highlight scientific progress in the field of ectogenesis’ (Petersen 2023). From this, we can see the intended purpose of the EctoLife video was a work of science communication, which aimed to elicit high

engagement from viewers as opposed to speculative fiction or a commercial concept video. Nevertheless, the facility depicted in the video is fictitious and the video uses fiction tropes in their delivery, form and content to the extent that many commenters draw on them in their reactions. It should also be noted that alongside his science communication work, Al-Ghaili has also produced short science fiction films and has self-published a science fiction novel. However, Al-Ghaili has not publicly stated that his EctoLife video should be considered an original work of fiction.

As of 10 December 2024, the video had been viewed approximately 3.3 million times. Given how frequently commenters mistake the EctoLife video for a real-world artificial womb facility, the comments prompted by the video potentially serve as a window to how some members of the public might perceive complete ectogenesis involving humans. However, past research that uses YouTube comment data highlights the polarising and often offensive language found therein (eg, Bou-Franch and Garcés Blitvich 2014). Furthermore, research shows that people of certain demographics tend to use YouTube more than others. Specifically, the audience of YouTube videos slightly skews male, is typically aged between 25 and 34 years, with the highest proportion of traffic coming from the USA (Zote 2024). As such, these findings cannot necessarily be generalised to the public as a whole. Nevertheless, as it is currently impossible to elicit reactions towards real complete ectogenesis technology, and as such reactions to this video serve as a first step in establishing what general public reaction could look like. While this research may also highlight particular hurdles that science communicators and marketers must overcome when discussing complete ectogenesis, it is also important to remember that the findings are strongly influenced by the framing of the EctoLife video. As such, they may not be generalisable to other science communication efforts on the topic which do not use such framings.

In the title of the video, EctoLife is described as ‘The World’s First Artificial Womb Facility’, claiming it can grow >30 000 babies a year (Al-Ghaili 2022). The video depicts a large industrial hangar filled with ordered rows of transparent, egg-like pods, each housing a white-skinned fetus. At the centre of the facility, two large tanks of fluid pump nutrients to and from the surrounding pods, while scientists in protective suits patrol the area with clipboards and pens. The facility is depicted in a dark black/grey industrial style with low brightness. The video also features the use of many stock assets used to portray the facility. There are also blue, angular, complex-looking technological overlays, which highlight different features of EctoLife and which represent a wealth of information being tracked about the infants. Together, these design choices give the facility a cold industrial aesthetic, while the stock assets give the video an uncanny feel.

The video itself is framed as an advertisement, speaking directly to the viewer in the second person. The voiceover tells us that ‘premature births and caesarean sections will be a thing of the past’ and explains how the technology allows you to ‘say goodbye to the pain of childbirth’. The video then shows how couples might customise their baby (including their height, skin colour and level of intelligence) using the real-world gene editing tool CRISPR-Cas9 (Ran *et al* 2013). They can also use a dedicated app to track the baby’s development day and night, even getting a direct view from the baby’s pod. Being able to customise one’s baby is referred to in the video as ‘the elite package’ and is available to consumers who are willing to pay a premium.

Fast-tempo music plays in the background of the video, which sounds somewhat futuristic, consisting of electronic sounds mixed with occasional piano notes and drums. The music mixes optimistic and slightly melancholic elements, and when the 'elite package' is discussed, the music modulates in a way which somewhat evokes the supernatural. The video is also narrated by a somewhat artificial-sounding female voice.

While the majority of the video is animated and includes somewhat uncanny animations of adults, embryos in the pods and fully developed babies, this is interspersed with some live action footage of human families enjoying time together with their newborn babies. These happy, smiling couples are quite diverse, and come from a range of ethnic backgrounds—in contrast with the rows of white-skinned babies presented in the opening scenes of the video. The video then closes with a short segment showing how EctoLife pods can also be set up in people's homes, with EctoLife pods installed in family bedrooms without the need to visit the main EctoLife facility. The video ends with the tagline: 'EctoLife: Reinventing Evolution'.

DATA COLLECTION AND ANALYSIS METHODS

Data for the study were collected on 13 June 2023 using a bespoke scraper created by Dr Andrew Hardie in the ESRC Centre for Corpus Approaches to Social Science at Lancaster University. At the time of data collection, there were a total of 15 548 comments and 382 057 words.¹ Given the size of the dataset, we used techniques from corpus linguistics to help us identify key themes and trends that characterised the dataset. Corpus linguistics is the computer-aided analysis of large datasets, where specialised software is used to carry out different kinds of searches and statistical tests. For example, specific words/phrases can be searched for, along with where they are used in their immediate context. It is also possible to calculate which words are more frequent and statistically significant (key) in one dataset compared with another. This technique is known as keyword analysis and keywords tend to reveal the most common topics discussed in the dataset (Scott and Tribble 2006). This approach also allows for key semantic domain analysis (Rayson 2008), where individual words are grouped into different semantic domains (eg, topics such as 'The Media: Books') and then these domains are tested for 'keyness'. This can be a useful way to capture words that are not frequent enough to be keywords on their own but are used to discuss a semantic domain that is key overall.

As keywords and key semantic domains are inherently comparative measures, we chose a video posted by Insider Tech, a technology-focused branch of the financial and business news outlet Business Insider, which showcased a real development in artificial womb technology known as the 'Biobag' (Partridge *et al* 2017), to compare the EctoLife video to. Here, scientists demonstrate placing a premature lamb fetus in the Biobag and seeing the fetus develop as would be expected outside of the ewe's body (Insider Tech 2017). This video reports on factual preclinical research undertaken at the Children's Hospital of Philadelphia. We chose this video as a comparison point for two reasons. First, it had a similar number of comments to the EctoLife video at the time of data collection (which aided the statistical element of the analysis). Second, it was a factual video about genuine partial ectogenesis developments, which directly contrasted with the EctoLife concept video. This meant that the fictional nature of EctoLife would be highlighted when we calculated the keywords and key semantic domains.

Table 1 The statistically significant keywords that were considered for this study, ordered by log ratio score

Keyword	Frequency	Log-likelihood score	Log ratio score
sci-fi	85	45.61	2.79
fiction	52	27.59	2.76
dystopian	134	70.74	2.75
science fiction	68	34.71	2.66
star	50	23.19	2.44
Aldous Huxley	48	19.25	2.16
horror	77	29.18	2.06
fantasy	38	14.23	2.04

To conduct our analysis, we used the corpus analysis tool Wmatrix V.5 to generate keywords and key semantic domains, which we assessed within their immediate contexts. This context was 75 characters to either side of the relevant word—extending our reach to the whole comment in cases where the immediate context was not sufficient. This established whether the word was relevant to our research questions and to establish how it was used in context. To generate the keywords and key semantic domains, we applied two statistical cut-offs: a minimum log-likelihood score of 6.63 (corresponding to $p < 0.01$) and a minimum log ratio score of 2 for the keywords and 1 for the key semantic domains. Whereas log-likelihood 'tells us how much evidence we have for a difference between two corpora', log ratio shows how big this difference is (Hardie n.d.). A log ratio score of 1 means that a word/semantic domain occurs twice as common in the target corpus and a score of 2 means the word/semantic domain is four times more common. We also applied a frequency cut-off of 5 to ensure that the terms captured were sufficiently characteristic of the whole corpus.

Of the 78 keywords that were established using this methodology, eight were identified as relevant to our study of specific fiction and genre references (table 1). The specific genres referenced in the comments were science fiction, horror, dystopian fiction and fantasy, to some extent. However, the terms *fiction* and *fantasy* were more often used in more general terms to describe the fictional nature of the video, rather than a specific genre (ie, fantasy), and so are not our focus. The specific fiction references visible in these keywords are *star* (used overwhelmingly in the phrase *Star Wars*) and *Aldous Huxley* (author of the dystopian novel *Brave New World*).

Two out of 29 semantic domains were significant to our research questions. The first was 'Electricity and electrical equipment', which included *robot*, *robots* and *robotic* among other words, which did not reference specific works of fiction, genres or entities associated with particular genres (eg, *electricity*). This domain had a log-likelihood score of 58.75 and a log ratio score of 1.13. The second was 'The Media: Books', which included words on the topic of literature such as *book(s)*, *hero(es)*, *author(s)*, *chapter* and more. This domain had a log-likelihood score of 34.07 and a log ratio score of 1.09. These domains were used to capture the salient fiction and genre references in the comments.

FINDINGS

Our findings are divided into three sections: genre references, comments on the purpose of science fiction and then finally, references made to specific works of fiction in the YouTube comments. In the discussion that follows, quotations from the

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comments are presented as display quotes, with important terms highlighted in bold, while the keywords are presented in italics. The quotations in this section were selected as they were representative of the trends visible in the data as a whole.

As readers will notice, one of the most striking findings to emerge from our analysis is the sheer lack of positive comments about the ectogenesis technology as presented in the EctoLife video. While we would very much like to have engaged with narratives that run counter to the prevailing negativity in the comments, there were not enough to warrant an extended analysis.

Genre references

When commenters describe the EctoLife video as a work of fiction, they often refer to it as science fiction, horror fiction and/or dystopian fiction. Often, these genres are used to negatively evaluate the technology presented in the video, with multiple users referring to artificial wombs as ‘dystopian sci-fi’, ‘dystopian nightmare’ or ‘dystopian hell’. Some users acknowledged that the video is not real, as in (1), where the video is described as a ‘sci-fi project’, and they refer to Hashem Al-Ghaili as the author of a fictional work:

1. this video isn't even real. It's a video someone made for a sci-fi project

Others, however, interpreted the video as reporting real-world scientific developments and expressed strong negative reactions to the video using references to religion, as in (2), where EctoLife is described as ‘satanic’, and in other posts where EctoLife is described as being against the will of God. Meanwhile, some users expressed resistance to EctoLife by claiming that the creators are in some way ‘playing God’, as in (3).

2. This is horrifying [sic] than any **horror movie**. Disturbing and **Satanic**

3. Seems like a preview to a **dystopian movie**. Maybe we should **stop trying to play God**

Sometimes the genres co-occurred, showing that users drew connections between them, as in (4) and (5), where sci-fi and horror, and dystopian and sci-fi were mentioned as being in some way hybrid:

4. Wtf is this. A trailer for a **sci-fi horror movie**? If so, I'm intrigued. If real, burn than [sic] crap to the ground please.

5. This feels like a **dystopian sci-fi** world we're entering.

These are interesting comments because they reflect a debate within science fiction studies about the nature of science fiction and whether it is a genre in its own right, or better thought of as a hybrid genre. Indeed, Baker argues that ‘the attempts to revise the very name of SF (to, eg, speculative fiction) indicate the unease within the genre with attempts to define it, to categorise it, to bring it to heel’ (Baker 2014, 19). This is certainly supported by the many YouTube commenters who considered science fiction, horror and dystopia as often being blurred.

Both the visual aspects of the video and the description of the technology’s capabilities prompt these hybrid genre comparisons. In terms of visuals, users describe the EctoLife facility as a ‘massive factor[y]’, as in (6), thus focussing on the size of the facility and the number of fetuses therein. Multiple users refer to its ‘brutalist’ appearance (7), while some refer to the incubators themselves as being evocative of science fiction, as in (8). Thus,

the factory design is integral to triggering negative responses in viewers.

6. Having babies begotten by **massive factories** sounds **dystopian**
7. Why did you have to make this so **brutalist** and **dystopian** looking?
8. **science fiction** baby incubators

Other users, when arguing that EctoLife was not real, suggested that the visual and sound elements of the video are too akin to science fiction to be taken seriously, as in (9) and (10).

9. This is a concept using a ton of stock videography, sci-fi CG, and an incredible amount of junk science
10. I'm not sure how seriously to take this, given that they're trying to sell it with **dystopian sci-fi music**

Certainly, the way the video is presented adheres to what scholars might describe as the ‘visual language’ of science fiction (Telotte 2001, 17–19)—especially in terms of the industrial design of the lab facility, dark colour scheme and computer-generated effects, which appear as a ‘foregrounded attraction’ (Cornea 2007, 250). Indeed, the video exhibits the same ‘devotion to technological display’ that Cornea notes in her analysis of science fiction cinema Cornea (2007); especially the way it emphasises the remote surveillance of pods in a way that is reminiscent of George Orwell’s dystopian novel, *Nineteen Eighty-Four* (1949)—a point we expand on later in this article.

Beyond surveillance, the genetic modification aspect of EctoLife also prompts comparisons with dystopian fiction and horror, leading to many negative evaluations. For example, some users likened this aspect to what they have seen in specific works of fiction such as Andre Niccol’s dystopian science fiction film *Gattaca* (1997), which has genetic modification at the centre of its plot. Meanwhile, others referred to a more general concept of ‘sci-fi movies’, as in (11), where these films are negatively evaluated as providing inspiration for the technology. These negative evaluations are expressed through strongly emotive language, as visible through the insult ‘sick fuck’ and appeals to the second coming of Jesus Christ. Thus, genre references and emotive language combined to strengthen the negative reactions to the video.

11. Someone watched too many **sci-fi movies** growing up. This is straight from the mind of Satan. Gene editing humans? What **sick fuck** would think they could **play God** and customize people to their liking? Please Lord Jesus come soon

Users also considered the possibility that the widespread use of an EctoLife facility would result in a future dystopian society with a malevolent end goal. For instance, one comment (12) echoes the plot of *Brave New World* to some extent by insinuating that, as a ‘dystopian next step’, EctoLife could be used to create classes of people based on their wealth. However, it is interesting that the commenter did not explicitly reference *Brave New World*, as this could suggest that the influence of this work goes beyond those who have read the novel or seen a film adaptation of it.

12. **Dystopian next step**: poor peoples [sic] babies are class D. Middle class get C and B, depending on skillset. Rich people class-A, skillset does not matter. And lab grown are S-tier, future leaders of politics and economy. Your number limits your possibilities in life, jobs and so on

To argue that EctoLife is part of a wider dystopian narrative, other commenters draw on the often anti-Semitic language used

by popular conspiracy theories (Christiansen and Au 2023; Flores 2022; Pautz 2016). This is demonstrated in references to ‘the Great Reset’, the World Economic Forum (WEF) and ‘New World Order’ (NWO), as in (13).

13. So Dystopian this is the **beginning of the Great Reset** 100%

The Great Reset refers to a somewhat broad conspiracy theory that the COVID-19 pandemic was orchestrated by world leaders to take control of the world economy (Christiansen and Au 2023). The name comes from the ‘Great Reset initiative’, an economic recovery plan created in 2020 by the WEF to address the effects of the pandemic (Christiansen and Au 2023). The NWO is a related term, which refers to ‘a conspiracy theory in which adherents believe that a cabal of powerful elites is secretly implementing a dystopian international governing structure that will grant them complete control over the global populace’ (Flores 2022). In conspiracy theory contexts, ‘globalist’ refers to the agenda of the so-called ‘elites’ controlling the NWO, as they are framed as seeking global control and domination—an agenda that transnational organisations (such as the WEF) are seen as promoting (Pautz 2016). It is unclear whether commenters believe that Al-Ghaili himself is part of the conspiracy, or whether EctoLife could instead be used by others for nefarious ends.

Specifically, some commenters argued that EctoLife could be used to achieve the goals of those who support the notion of a Great Reset or NWO by creating obedient humans. For instance, in (14), the ‘NWO’ is constructed as beneficiaries of EctoLife who wish to ‘replace humans with robots’ in order to have ‘full complete control’.

14. They are trying to **replace humans with robots** this is the **new world order** they want to erase humans so that they can have full complete control

As Christiansen and Au (2023) suggest, conspiracy theories can thrive in contexts where information on a topic comes from multiple sources, and it is unclear which sources can be trusted. The resulting feeling of overwhelm can lead those interested in such topics to seek a theory that appears to explain the phenomenon in straightforward terms. The topic of complete ectogenesis certainly lends itself to this, given that as the technology is still in its infancy and many different representations of it exist in fiction. Furthermore, similarities can be drawn between certain visual elements of the EctoLife video, such as the low brightness and use of dark colours, and videos that propagate antisense conspiracy theories (Chen *et al* 2022). This has clear implications for future science communications on complete ectogenesis, as visually prompting associations with common conspiracy theories should be avoided whenever possible.

The terms *robot*, *robots* and *robotic* appeared when commenters argued that EctoLife would be used to replace human children with robots, and are common in the dataset, despite the fact that robot children did not appear in the original video. Although some commenters explicitly referred to the conspiracy theories noted above to make this argument, this was not always the case. Others linked the idea of humans being replaced with robots to current technological developments, such as artificial intelligence (15), while others viewed humans becoming (or being replaced by) robots as inevitable, as in (16):

15. This world is being **taken over by robots** and most **dangerous artificial intelligence**. 21st century is the end of the human era I think.. 🤖 🤖

16. This is mad no one do it I swear at this point we’re all gonna be robots

Some commenters referred to the infants produced via EctoLife as being robots themselves, as in (17), where being ‘human’ was framed as antithetical to being a ‘robot’ in a form of grammatical parallelism. Others combined these notions in a single phrase such as ‘human robot’ or ‘biological robot’, as in (18). This indicates that some commenters did not perceive robots as necessarily shiny metal entities and, instead, as flesh and blood.

17. They are **not human** they are robots

18. they are making **human robots not human baby**. 🤖

Interestingly, these concepts perhaps unknowingly allude to the first ever recorded use of the word ‘robot’, as used in the 1920s with Karel Čapek’s play *R.U.R.*, or ‘Rossum’s Universal Robots’ (Čapek 1920). In his original use of the word, Čapek described robots as ‘humans capable of work but not thinking’ (Čapek quoted in Horáková and Kelemen 2008, 285)—thus blurring the distinction between human and machines right from the very start (Ryder 2020). In making these arguments, users raise concerns that infants created using the EctoLife technology would be ‘programmed’ using this technology to carry out the will of their controller. This controller was typically seen as a ‘government’ or ‘state’ as in (19) but was also sometimes referred to ambiguously using the third person ‘they’. This lack of autonomy is also framed in the absolute terms ‘complete’ and ‘unquestioning’. This sets infants who are naturally gestated apart from infants created using the EctoLife technology.

19. the **state will now be able to grow biological robots**, completely loyal to them. Who will **unquestioningly obey them**, work for food

Meanwhile, some users suggested that those born this way would lack emotional depth and would be ‘soulless’, as in (20); or that they would be unable to show love and kindness to others, as in (21). In (21), the term ‘soldiers’ suggests that EctoLife could be used for military purposes as the children would not feel compassion for their fellow human beings and thus could act as effective soldiers. As (21) shows, human ‘soldiers’ are equated to ‘robots’ due to lacking these qualities that are framed as innately human. This theme is visible in other works of fiction referenced in the dataset, such as *Star Wars*, as we discuss below.

20. They want to breed human-like creatures that you don’t know what’s been injected into **their soulless robotic brains**

21. This is just an excuse to grow soldiers, **children without any form of love and kindness**, cold hearth [sic] robots but cheaper to sustain

This perceived lack of emotion and autonomy, in turn, led commenters to believe that infants created using EctoLife would be violent towards humans. This is framed in terms of an ‘army’ or ‘armies’ being created, as in (22), where it is suggested that EctoLife infants will influence or kill ‘real people’ in order to replace the humans who were not created ‘with the minds of robots’. The terms ‘army’ or ‘armies’ were used to refer both to EctoLife being used for military purposes and to the sheer number of people being created. Users also highlighted the physical strength of the infants, as in (23), where ‘high strength’ is contrasted with ‘low intelligence’ and unthinking subservience. To some extent, this theme is also visible in *Brave New World*, where the Delta and Epsilon (the lower class) citizens are created for the purpose of unthinking manual labour and, as a result,

are created to possess physical resilience and low intelligence (Huxley 1932, 11–12). Overall, these findings indicate that avoiding allusions to robot-like behaviour is key to avoiding negative reactions to the technology.

22. so you're telling me you can make **armies of humans** with the **mind of robots** since birth? **program** them to submit to every single order given to them, and use them for 70years either to **propaganda/invide** [sic]/**Kill the other REAL people?**

23. I think we should be worried. Maybe this will halt robotics research. I mean why keep going. Build a bunch of low intelligence **high strength human robots** who can live on this sludge they grow babies with.

By way of counterexample, one commenter (24) acknowledged the potential positive applications of the technology alongside the genetic modification aspect, which they considered to be 'dystopian horror'. On the rare occasion that users acknowledge the potential positive applications of the technology, they tended to discuss it in terms of making it easier for women who do not wish to experience pregnancy, for those who are infertile and for men not in relationship with women. They also discussed the reduced risk of genetic abnormalities in the child if the EctoLife technology were used. Despite these potential benefits of the technology, the majority of comments below the EctoLife video were overwhelmingly negative:

24. This is amazing for people who find themselves to be the exception; the ones who survived cancer and lost their womb, or etc. But, Jesus, the lengths they want to go with this type of stuff, to modify genetic data like a character creator in some game... **The good it offers is almost immediately washed out by the dystopian horror.**

Meanwhile, multiple commenters critiqued the video's language, with users arguing that word choice evoked comparisons with dystopian fiction. Specifically, the video claims that the parents will be able to control aspects of the technology from their home, and their home is referred to as their 'zone'. Commenters described this as dystopian as in (25), highlighting how word choice (from science communicators or others) can affect the perception of scientific developments.

25. 2:00 track your babys [sic] health from the comfort of your ***zone*** - the hell is **this dystopian shit**

Overall, our findings show that users predominantly react to the EctoLife technology in a negative way, drawing on common tropes from the genres of horror and science fiction to anchor their arguments to pre-existing, well-established concepts. This negative response includes the capabilities of the technology, how it is presented and the potential ways it could be exploited by nefarious actors.

What do YouTube commenters think science fiction is for?

When referencing science fiction, horror and dystopian fiction, commenters considered the role that works of fiction from these genres play for their readers. As opposed to being interpreted simply as sources of entertainment, science fiction and dystopian fiction are commonly interpreted as predicting the future, whether that be because science fiction can be viewed as 'inspiration' or because science fiction authors themselves are seen as predicting future developments:

26. Today's **sci-fi is tomorrow's reality**...just as yesterday's sci-fi is today's reality...partly because **human uses sci-fi as an inspiration for technological progress**, but before all mostly because sci-fi conceptors

tend to use their ability to glimpse, to have inklings into the most probable future (of humanity...)

Most users who claimed that science fiction and dystopian fiction predict the future argued that works of fiction from these genres should be interpreted as warnings against the use of harmful technology in the future. This is often expressed with somewhat vague references to 'books', 'movies' and science fiction generally, as in (27), where the quantifier 'all' is used to emphasise the sheer volume of science fiction works with this supposed warning message, and so express incredulity at those embracing the EctoLife technology. This is in contrast to referencing specific works of fiction (discussed below), which is comparatively rare.

27. **All the warnings from sci-fi** and still there's a lot of idiots embracing it.

This is also visible in (28), where the commenter made general reference to 'the plots in those dystopian stories' without specifying the details of these plots. This demonstrates an orientation to a wider cultural understanding of what dystopian stories entail, as opposed to a specific facet of the genre. Where more details are specified, such as the mention of 'a dystopian government' using the technology to control its population in (29), specific works of fiction are not named.

28. I'm disgusted by **the plots in those dystopian stories** and here we are with psychopaths trying to recreate them in real life! Disgusting!
29. this tech has been featured in books where a **dystopian government controls everything** about your life

Furthermore, some commenters suggested that the creator of EctoLife had taken inspiration from works of science fiction, claiming the creators had wrongly interpreted science fiction as a 'documentary', 'blueprint', 'handbook', 'instruction manual' or 'how-to guide', as in (30), as opposed to the warning that works of science fiction are (supposedly) intended to be.

30. So, when you guys watch science fiction dystopian movies or read those types of books... you didn't see them as cautionary tales? You saw them as freakin' **"How To" guides???**

These layperson interpretations of the purpose of science fiction are somewhat reflected in Miller (2012, 15), who has suggested that 'science fiction [...] always reflects our reality, but it also points the way to other possibilities—it is both cognitive (realistic) and estranging'. Indeed, Fitting (2010, 138) referred to this reflection-of-reality as a 'foundational characteristic' of science fiction, especially in the way that it links our hopes and fears for science and technological progress. Although both Miller (2012) and Fitting (2010) have recognised the potential for science fiction to be hopeful and point to more positive utopian ways of living, the EctoLife video most strongly evokes the dystopian aspect of science fiction—which science communicators should avoid when working in this area. Nevertheless, these comments indicate that elements of the video which resembled science fiction led to commenters believing well-established warnings were being ignored by the developers of the technology.

A smaller number of commenters argued that the purpose of science fiction is to prime its audience for incoming technological developments that the science fiction authors are aware of, but the public are not. This is commonly discussed in terms of 'programming', as in (31), where works of science fiction are seen as factual, and the presence of technology that appeared in science fiction from the 1970s is given as evidence of this.

31. They were not fiction movies...they were programming movies designed to make you comfortable and welcoming when they become reality...Most if not all the gadgets that were shown in Sci Fi movies of the 70s are all realities today

Although this comment itself does not provide specific examples, it is notable that we can read the tricorder device from *Star Trek* as a precursor to the widespread acceptance of handheld computer technology (smartphones) in everyday life. Other examples include the ‘artificial intelligences’ and AI assistants described in works such as Robert A. Heinlein’s *The Moon is a Harsh Mistress* (1966) and Frederik Pohl’s *Gateway* (1976). When statements such as those in (31) draw on real-world developments in their argument, fact and fiction are viewed as indistinguishable. This is in line with definitions of science fiction that discuss its ability to reflect reality (Fitting 2010), but it complicates efforts in science communication where it is important to distinguish truth from fiction.

References to specific works of fiction

Based on the keyword and key semantic domain analysis, the works of fiction that are most commonly referred to with regard to the EctoLife video are the 2002 film *Star Wars: Episode II—Attack of the Clones* (and the subsequent animated shows titled *Star Wars: The Clone Wars*) and the 1932 novel *Brave New World* by Aldous Huxley. It should be noted that the terms in ‘The Media: Books’ are used overwhelmingly to refer to *Brave New World*, although certain religious texts such as the *Book of Daniel* and the *Book of Revelations* are also discussed.

Star Wars and *Brave New World* are, arguably, vastly different works in terms of being different forms of media, produced at different times and with different tone and plot. Nevertheless, both explore themes of the population being controlled, although in very different ways with the Empire exerting violent control in *Star Wars*, and the government (the World State) exerting control by manipulating embryos and psychologically manipulating its population in *Brave New World*. The protagonists of each fictional work rebel against this control. Both texts are also extremely popular, with *Star Wars* being one of the most high-grossing media franchises of all time (Statista 2024) and *Brave New World* being adapted into films and television shows even today (eg, the 2020 adaptation on Apple TV) and being taught in schools. Indeed, Kendal (2018) notes that the popularity of *Brave New World* certainly contributes to the amount it is referenced in academic texts compared with other works of speculative fiction.

The connection between *Star Wars* and *Brave New World* has also been observed in the academic literature, with Dinello (2005) making a direct link between the film *Star Wars: Episode II—Attack of the Clones* and the incubation wombs mentioned in *Brave New World* (211). It is also interesting how the *Star Wars* depiction of cloning and artificial wombs aligns so closely with the *Brave New World* depiction, with one science fiction vision being shaped by another, restating and reaffirming the same fears Huxley made evident in 1932. Indeed, Sweet (2016, 55) notes in *Star Wars* how ‘the nearly endless rows of oversized test tubes inhabited by developing clones are reminiscent of the stream of goods often associated with an assembly line’. In the case of *Star Wars*, the clones become a kind of manufactured commodity—much as the newborn infants are manufactured commodities in EctoLife.

These works of fiction are particularly relevant because the technologies they present, specifically the artificial womb technology and gene editing capabilities, have either ‘come to

fruition’ (Dinello 2005, 190) or seem increasingly imminent. It is not so much a question of whether the technology currently exists. Rather, the world it presents seems plausible, moving from ‘the foreseeable future to the immediate present’ (Paschalidis 2000, 43). This is certainly the case for gene editing due to the creation of the gene editing tool CRISPR-Cas9 (Ran *et al* 2013), and for ectogenesis where partial ectogenesis technology is presently being developed (eg, Partridge *et al* 2017).

Furthermore, the fact that commenters drew on such dystopian works arguably reflects a zeitgeist characterised by polarised politics and fear of increasing government encroachment on personal freedoms (eg, Kim *et al* 2023). Indeed, comments that expressed fear over EctoLife being used to limit personal freedoms do not exist in a vacuum separate from the political context within which they were written. For example, the overturning of *Roe v Wade* in the USA and the consequences this has had for reproductive rights may legitimise these fears. Meanwhile, on the political right, some resisted the lockdowns and vaccine measures necessitated by the COVID-19 pandemic as this was seen as infringing on personal freedoms. This shows how, across the political spectrum, people’s perception of emerging technology may be affected by (inter)national events.

When *Star Wars* is mentioned by commenters, it is in reference to the army of clones who are created to fight with, and then ultimately betray, the Jedi. Commonly, users note that the EctoLife video reminded them of the ‘clone wars’, the main conflict in *Star Wars Episode II: Attack of the Clones*, which is between the Republic and the Separatists (who were secretly led by an evil Sith Lord). References are made to the EctoLife technology being used to create a ‘clone army’, as in (32). Multiple groups are constructed as beneficiaries of such an army, including the military as in (32) or a company using the technology to create ‘slaves’ for commercial purposes, as in (33).

32. ...or you can make a clone army like the one in *Star Wars*! The military might make use of that

33. A huge company will take this to make free slaves or soldiers like the clone troopers in the *Star Wars*.

Similar to how the term ‘robot’ is used to describe humans born from the artificial wombs, ‘clones’ here are described as easily controllable and so can be used for nefarious ends. Occasionally, commenters showed in-depth knowledge of *Star Wars* and extended the reference to include ‘Order 66’, which is the command that turns the clone army against the Jedi, as in (34).

34. Reminds me of clone wars in *star wars*...Then what happened? Execute Order 66. As the Clone Wars draw to a fiery close, Chancellor Palpatine begins his endgame and brands the Jedi Knights enemies of the Republic.

By referencing this, commenters implied that the children created using EctoLife could be turned against other people and would not have the capacity to think for themselves. Overall, this reflects users’ distrust of the technology in a way which echoes the conspiracy discourse discussed above.

As for *Brave New World*, the novel is arguably the single most famous science fiction novel to describe ectogenesis, genetic engineering and related techniques (Seed 2008, 477). In the novel, citizens are created in artificial wombs in a facility called The Central London Hatchery and Conditioning Centre. In this facility, the intelligence and physical features of the embryos are engineered to create a caste system with its citizens, and each caste is designed to fulfil a specific purpose in society. This is then reinforced by psychological conditioning and through the

population using a drug called soma to suppress strong emotions and elicit a feeling of happiness. Seventy per cent of the female embryos created in the Hatchery are sterile, meaning that the Hatchery is the primary means of producing new people in Brave New World. Commenters referenced these elements of the book to draw comparisons between the setting and the creation of children in the EctoLife facility, and they implied that the technology would be used in a similar way. For example, this is evident in (35), where the commenter argued that the EctoLife facility would be used to create ‘engineered babies... manipulated for some specific careers’, thus directly referencing the caste system in Brave New World. This theme of a lack of free will also echoes the discussions surrounding Star Wars and various uses of the word *robot(s)* as described above.

35. This is right out of Aldous Huxley’s book “Brave New World”. I pity this & future generation’s [sic] of **engineered babies**. They may not be telling their clients yet that **the babies brains will be manipulated for some specific careers, could be Janitors or Assassins!**

Interestingly, several users such as in (36) also quoted directly from the end of Brave New World, where John (also referred to as The Savage) rejects the lifestyle of those living in London and proclaims his desire to experience strong emotions and potentially negative events. By aligning themselves with this quotation, these commenters seem to be rejecting the EctoLife technology and what it represents for them.

36. “But I don’t want comfort. I want God, I want poetry, I want real danger, I want freedom, I want goodness. I want sin.” —Aldous Huxley, Brave New World **Brave new world is going to be the future, combined with 1984.**

Also visible in (36) is the commenter referencing George Orwell’s dystopian novel Nineteen Eighty-Four (1949), and several commenters made a similar connection between the two novels. Nineteen Eighty-Four, like Brave New World, is a dystopian novel set in London. In both novels, a totalitarian government rules the people—the Party led by Big Brother in Nineteen Eighty-Four and the World State in Brave New World. Both novels explore how one might rebel against such governments. Both novels explore the theme of control over the people, which is achieved through use of technology and psychological conditioning. In Nineteen Eighty-Four, ‘telesccreens’ are used to conduct mass surveillance on the people and ‘doublethink’ (the ability to believe two contradictory beliefs at once) is encouraged so that the people accept the Party’s rewriting of historical events and facts to suit their ends. Furthermore, there is a class system in both novels, with the upper class in Nineteen Eighty-Four undergoing less surveillance than the middle class and the lower class ‘proles’, and having access to more luxuries. The novels do, though, significantly differ in the way that they ensure compliance from the public, with the citizens in Brave New World biologically altered to feel content with their lives, whereas the citizens in Nineteen Eighty-Four are controlled through fear, surveillance and torture, as Huxley (1958) himself noted. Overall, this suggests that users may be less interested in drawing on the nuances from each work that they mention and instead rely on their similarities.

Comments that elaborated on the details of Brave New World were rare. Most commenters only gave the name of the book in their comment with no accompanying information. When discussing the book in more general terms, users referred to the dystopian setting of Brave New World and argued that the book acts as a warning against supporting technology such as EctoLife.

For example, in (37), the commenter described Brave New World as a ‘dystopian nightmare’, which is at risk of becoming realised:

37. If ppl [people] don’t wake up soon **this is Aldous Huxley Brave New World dystopian nightmare** come to life!!

Some users also interpreted Brave New World as predicting future technological developments and so they argued, in strongly emotive terms, that such technology must be opposed in order to avoid apocalyptic consequences, as in (38), where ‘grinning vacantly’ can be interpreted as referencing the effects of the soma drug. However, it should be noted that the world does not end in the novel, thus showing how the YouTube commenters add their own interpretations to the novel, and do not draw solely on its content.

38. In 1932, Aldous Huxley wrote Brave New World as fictional description of a dystopian future. Less than a hundred years later... wave the magic wand... *poof*... here we are... **plunging headlong into Armageddon and grinning vacantly.**

Commonly, users tell one another to read Brave New World due to its perceived relevance to the EctoLife technology. However, despite this recommendation, which would suggest that the person recommending it has a strong knowledge of the book, many users gave different dates for its publication (1929, 1931, 1932, 1934 and the 1950s), despite the book being widely available (see: Huxley 1932). Meanwhile, one commenter incorrectly names Isaac Asimov as its author, and another misremembers there being four classes in the book as opposed to five. These incorrect details, combined with the lack of detail in most of the comments referencing the novel, indicate that these users are perhaps not as familiar with it as their comments suggest. As a result, they may be drawing on a certain common cultural memory of what the book is about, rather than their own personal knowledge of it. This arguably reflects a key facet of science fiction as demonstrating ‘an *awareness* [our emphasis] of the effects and importance of science and technology [...] the role of technology as a tool for social transformation’ (Fitting 2010, 139). It is this awareness that shines through most strongly in the comments under the EctoLife video, as commenters are aware of key texts from the genre as opposed to specific details. What is important is the feeling that the science fiction conjures—a kind of intellectual shorthand for the message that these key works of science fiction deliver. This also echoes observations from Chan (2009, 298), who argues that Brave New World is used as ‘a form of metaphorical shorthand for an underlying argument’ in the academic bioethics literature as well.

CONCLUSION

In this paper, we have investigated the references to genres and specific works of fiction in comments made in response to Al-Ghaili’s EctoLife video (2022). Commenters referenced science fiction, horror and dystopia in general terms to negatively evaluate the EctoLife facility depicted in the video. Similarly, when users drew comparisons between EctoLife, Star Wars and Brave New World, they most often discussed these works of fiction in general terms rather than referencing specific elements. Commenters also expressed fear that complete ectogenesis technology would be used as a tool of oppression in a way that draws on the current zeitgeist. To an extent, this mirrors Cavaliere’s (2020) concern that the practical implementation of ectogenesis technology would be rooted in, and thus reflect and reify, how society currently functions (ie, likely to perpetuate existing power imbalances). Furthermore, to some extent, Chan

(2009) fears that science fiction could turn the public against potential beneficial technologies is confirmed by our findings, although we note that the EctoLife video may be purposefully provocative to generate viewer engagement. While we recognise that our findings may not be generalisable to all members of the public because of the specific framing of EctoLife and the fact that YouTube attracts a particular audience, it is notable that academic literature on complete ectogenesis, much like the comments discussed here, makes comparisons with Huxley's *Brave New World* (1932). This indicates that such a framing is not exclusive to the non-academic and often antagonistic setting of a YouTube comments section, as it is drawn on by multiple audiences. Therefore, we argue that the salience of this literary reference should not be underestimated by science communicators in this area.

Furthermore, our findings highlight the dearth of positive popular science fiction narratives that the public can draw on to make sense of new technologies such as artificial womb technology. This echoes Kendal (2018, 70) argument that utopian fiction (eg, *Woman on the Edge of Time* by Marge Piercy) could be used to 'accurately communicate bioethical issues to the public in a nuanced and engaging way'. No matter what positive impacts a new technology may have, these benefits can be very easily lost if presented in a way that triggers negative associations. Indeed, drawing on the themes and iconography of well-known dystopic works of fiction, as the EctoLife video does, can quickly evoke justified negative responses as well as conspiracy theories for some users. While we cannot eradicate connections to conspiracy theories completely, we can at least work to mitigate the number of connections drawn to them. This is especially important in works of science communication for technologies with potentially emancipatory effects such as enabling fewer restrictions to be placed on those who gestate and bringing about more social equality between gestating and non-gestating people.

Kirby (2010, 42) has suggested that there are three key areas to overcome in any form of science communication to address user anxiety: the necessity of the technology; the 'normalcy' of the person(s) using the technology and the viability of the technology for practical use. There is also a need to demonstrate what Kirby calls the technology's 'benevolence', that is, its positive effects (Kirby 2010, 43)—something that is evident in our findings. Building on Kirby's (2010) research, there is a clear need for any technology related to human reproduction to focus on the individual human impact of the technology and its application. Any sense of mass production should be avoided if we are to achieve the emancipatory effects of reproductive technologies discussed in this article without its risks—both to the gestating person and fetus. It is also notable that the myriad references to *Brave New World* when discussing ectogenesis in academic and lay discourse alike come at the expense of focusing on real-world experiences of oppression that gestating people face and, potentially, different works of science fiction from a diverse range of authors (So *et al* 2022). It is important, then, that any new technology be framed in response to these issues, with the emphasis being on safety and quality of life, rather than the benefits of selective gene editing to make 'designer babies', as this risks moving far too close to dystopian science fiction.

As we cannot assume that all representations of complete ectogenesis would garner the same responses and fiction comparisons we found here, we encourage future researchers to investigate more public discussions of this topic. These investigations could consider the impact of gender, age and location on the findings, as this information was unavailable for our YouTube data. Future

research may also consider if and how the interactive, participatory nature of the YouTube comments platform shapes user responses. Similarly, a focus on the visual content of the whole EctoLife video could be used to further explore how certain visual cues can trigger negative responses and conspiracy theory associations. No matter what direction future work takes, it is integral to focus on how reproductive technologies could be used to foster equality and actively dismantle systems of oppression within reproductive healthcare.

Twitter Mike Ryder @RobotTheory

Acknowledgements The authors would like to thank all the members of the Future of Human Reproduction team for their help with revising this article, the attendees of the 2024 Critical Approaches to Discourse Analysis Across Disciplines (CADAAD) conference for their comments on a presentation based on this paper, as well as the anonymous reviewer for their invaluable comments on an earlier version of this paper. We would also like to thank Dr Andrew Hardie at Lancaster University for his assistance with data collection.

Contributors AK made substantial contributions to the design of the work, including the data collection and analysis methods. Both authors drafted the work and made substantial contributions to the interpretation of data, revised it critically for important intellectual content, approved the final version of the article and agreed to be accountable for all aspects of the work. Both AK and MR are guarantors.

Funding This study was funded by Wellcome Trust.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The study was approved by the Faculty Research Ethics Committee at Lancaster University (reference FASSLUMS-2023-3673-RECR-1) and the Faculty of Arts and Humanities Research Ethics Committee at the University of Southampton (reference 99779). The study was approved by two universities because the lead author moved institutions. Consent was not obtained from the YouTube commenters due to the public nature of the data. Furthermore, the large volume of data made it impractical to obtain consent from every individual user. It should be noted that no identifying information about users (including usernames) is presented in the study, and the discussion of the linguistic features of the data will focus on patterns observed across the data. Although it is important to quote directly from the data due to the linguistic focus of the research, a search engine query does not reveal the content of the YouTube comments.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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ORCID iDs

Alexandra Krendel <http://orcid.org/0000-0003-3935-9865>

Mike Ryder <http://orcid.org/0000-0003-3917-4609>

NOTE

1. The number of words was calculated using the corpus analysis tool Wmatrix V.5 (Rayson 2008).

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