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Pistols, pills, pork and ploughs: the structure of technomoral revolutions

J. K. G. Hopster ^a, C. Arora ^b, C. Blunden ^c, C. Eriksen ^d,
L. E. Frank ^b, J. S. Hermann ^a, M. B. O. T. Klenk ^e, E. R. H. O'Neill ^b
and S. Steinert ^e



^aPhilosophy, University of Twente, Enschede, Netherlands; ^bPhilosophy and Ethics, Eindhoven University of Technology, Eindhoven, Netherlands; ^cPhilosophy and Religious Studies, Utrecht University, Utrecht, Netherlands; ^dNational Center for Ethics, The Danish Ministry of Health, Copenhagen, Denmark; ^eEthics and Philosophy of Technology, Delft University of Technology, Delft, Netherlands

ABSTRACT

The power of technology to transform religions, science, and political institutions has often been presented as nothing short of revolutionary. Does technology have a similarly transformative influence on societies' morality? Scholars have not rigorously investigated the role of technology in moral revolutions, even though existing research on technomoral change suggests that this role may be considerable. In this paper, we explore what the role of technology in moral revolutions, understood as processes of radical group-level moral change, amounts to. We do so by investigating four historical episodes of radical moral change in which technology plays a noteworthy role. Our case-studies illustrate the plurality of mechanisms involved in technomoral revolutions, but also suggest general patterns of technomoral change, such as technology's capacity to stabilize and destabilize moral systems, and to make morally salient phenomena visible or invisible. We find several leads to expand and refine conceptual tools for analysing moral change, specifically by crystallizing the notions of 'technomoral niche construction' and 'moral payoff mechanisms'. Coming to terms with the role of technology in radical moral change, we argue, enriches our understanding of moral revolutions, and alerts us to the depths of which technology can change our societies in wanted and unwanted ways.

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KEYWORDS Moral revolution; moral change; technomoral change; moral niche construction; payoff mechanisms

CONTACT J. K. G. Hopster  j.k.g.hopster@utwente.nl  Philosophy, University of Twente, Enschede, Netherlands

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1. Introduction

The power of technology to transform societies, religions, science, and political institutions has often been presented as nothing short of revolutionary. The ‘Industrial Revolution’, a term coined around the turn of the nineteenth century,¹ remains a paradigmatic example of technology-driven revolutions, as recent discourse on the ‘Fourth Industrial Revolution’ (Schwab 2016) exemplifies. Similarly, printing technology has been heralded for its pivotal role in the Protestant Reformation initiated in Germany in 1517 (Holborn 1942), and the social media platform Twitter has been suggested as a key enabler of Tunisia’s ‘Jasmine Revolution’ during 2010 and 2011 (cf. Lowrance 2016). In science, technologies such as the microscope and telescope have been identified as important parts of revolutionary processes (Kuhn 1962).

Recently, philosophical scholars have also become interested in revolutions that play out in the moral domain (Appiah 2010; Baker 2019; Eriksen 2019, 2020; Pleasants 2018; see Klenk et al. 2022 for an overview). Echoing Kuhn’s account of scientific revolutions, Baker argues that moral revolutions involve a shift in moral paradigms, i.e. in ‘framework[s] of communal standards for character and conduct that a community’s members internalize’ (Baker 2019, 17). Paradigmatic examples of such revolutions are the abolition of slavery (Pleasants 2018) and the emerging equal treatment of men and women, where both cases involve radical changes to multiple aspects of moral life, such as changes in beliefs, sentiments, practices, and institutions.

It seems plausible to conjecture that technology, which has played a transformative role in revolutions that are predominantly social, religious, political, or scientific, has been an important contributor to moral revolutions, too. That said, since moral revolutions are highly complex events entangled with ensembles of practice (Jaeggi 2018) and influenced by a variety of causal mechanisms, it is an open question what role technologies play in them, and whether there are any generalities to this. At present, the role of technology in moral revolutions is both under-investigated and under-theorized. Scholars of moral revolutions do occasionally discuss the causal influence of technology (e.g. Baker 2019; Danaher 2020), but so far no systematic account of how technology can be involved in moral revolutions has been worked out. Philosophers of technology have, in recent work, paid substantial attention to how morality and technology co-evolve, and

¹The idea of a ‘revolution of industry’ emerged in circles of French economists in the late 18th century, in the wake of the French Revolution (Stedman 2002). Friedrich Engels popularized the concept ‘industrial revolution’ in continental discourse, and Arnold Toynbee later did so in Anglophone writings (Wilson 2014).

transform each other in the process (Swierstra, Stemerding, and Boenink 2009; Boenink, Swierstra, and Stemerding 2010; Swierstra 2013; Kamphof 2017; Nickel, Kudina, and van de Poel 2022). Yet scholarship of technomoral change has barely touched on questions of radical moral change at a societal level. Can technology instigate moral revolutions? Are there any general patterns to technology's role in processes of radical moral change? Apart from benefiting our theoretical understanding, these questions are important as their answers can help us detect, predict and avoid unwanted changes to fundamental moral beliefs and values due to the use of technology.

In this article, we broach philosophical inquiry into what we term 'technomoral revolutions'. We understand technomoral revolutions as processes of large-scale, radical moral change, whereby technology plays a noteworthy role in bringing the change about. Our contribution is twofold. First, we extend the scope of previous studies of technomoral change, by analysing four historical and contemporary candidate cases of technomoral revolutions. Secondly, inspired by these case-studies, we reflect on the structure of technomoral revolutions. More precisely put, we identify general mechanisms by which technology contributes to moral revolutions, and present analytical and conceptual tools to further this inquiry.

2. Technomoral revolutions and technomoral change

A challenge in advancing the concept of 'technomoral revolutions' is that neither technology, nor moral revolutions, have clearly recognized and uncontroversial boundaries. The concept of technology is polysemous (Carlsen et al. 2010): it may refer, for instance, to a field of engineering, to technical artifacts, or to the applications to which artifacts give rise (Brey 2012). Similarly, the concept of moral revolution may be understood in different ways: Baker (2019) highlights its activist-driven nature, whereas Appiah (2010) underscores the relatively short timescale of radical change, and Pleasants (2018) points to the cumulative nature of change. At the start of our current inquiry, we do not want to side with any of these accounts in specific. Neither do we assume a distinctive 'mark of the moral'; instead, we rely on a generic, society-centred understanding of morality, as consisting of sets of practices, beliefs and institutions indicative of what a society regards as obligatory and valuable. The case-studies we will be discussing concern *morally significant practices* that are socially embedded; we leave open the question of whether these practices can be regarded as moral practices in a purer sense. Accordingly, we will operate with an ecumenical, minimal

definition, according to which ‘technomoral revolutions’ consist of radical group- or society-level change in morally significant practices, whereby technology plays a noteworthy role.²

Group-level or society-level change is a broad phenomenon that typically involves changes in beliefs, attitudes, behaviours, as well as institutions. Change of this sort is discussed, among others, in the philosophical literature on moral progress (Buchanan and Powell 2018; Eriksen 2020; Hermann 2017, 2019; Jaeggi 2018; Kitchoer 2011, 2021; Klenk and Sauer 2021; Moody-Adams 1999; Smyth 2020; Singer 2011; see Sauer et al. 2021 for an overview). Yet, while the concept of moral progress is characterized by a positive evaluation of change, recent literature on moral revolutions tends to avoid this evaluation (e.g. Baker 2019; Eriksen 2020). Similarly, no such evaluation is part of our minimal definition, nor of our ensuing argumentation: while some readers might be inclined to interpret our case-studies in terms of moral progress or regress, we steer clear of making explicit moral commitments ourselves, and set aside the topic of progress in order to keep our discussion manageable.

As noted, the topic of technomoral revolutions is related to existing research on technomoral change, albeit with a shift of focus. First, the thematic focus of current case-studies of technomoral change is somewhat narrow (Nickel, Kudina, and van de Poel 2022), and primarily geared to the biomedical sphere. This focus is understandable: biomedicine is an area of rapid technological innovation and directly touches upon many morally salient issues that pertain to human health and human enhancement. Yet there are many other human practices and domains of social life where interesting case-studies of technomoral change are likely to be found. Consider agriculture, warfare, cooking, artisanry, sanitation, mobility, literacy, and communication. All of these are practices or domains where technological artifacts play a major role in mediating human perception and action. Furthermore, all of them shape the broader ecology in which human morality develops and evolves. As a result, we might expect interesting case-studies of technomoral change to be found in these domains as well. One worthwhile way of expanding research on technomoral change, then, is to broaden its scope, and investigate the full range of practices in which such change occurs.

²We do recognize, however, that in future inquiry, it might be fruitful to tease moral revolutions of different kinds apart, and to clarify the relations between the concepts of (technomoral) revolution, transformation, and disruption (Hopster 2021). We make preliminary moves in this direction in section 4.

A second feature of extant research on technomoral change – and the co-shaping of technology and society more generally – is that it is often geared to apparently mundane human-technology interactions. Taking cues from Latour (1992) and Ihde (1990), philosophers of technology have analysed in detail how apparently unremarkable artifacts and design features transform everyday practices and perceptions, often in unexpected ways Verbeek (2011) – for instance, how the increasing popularity of the now-common bicycle design (versus the ‘high-wheeler’ bicycle) challenged traditional gender roles (Bijker 1995, 1). While nothing is at fault with this level of analysis, we propose that a complementary focus on larger-scale, radical moral shifts can benefit scholarship. The philosophical literature on moral revolutions, as well as the historical literature on value change (Morris 2015), may supply an alternative starting point for this type of project. Rather than starting with a very specific technological artifact and scrutinizing its effects on everyday moral life, we take an opposite approach, starting with large-scale societal changes and subsequently scrutinizing the role of technology in these changes. This approach is likely to shed a different light on how technologies get entangled with each other, and with society at large.³

In the next section, we present four case-studies, each of which elucidates the dynamics between technology and morality in an instance of society-level moral change.⁴ The first case (pistols) was selected because it has recently been classified as a moral revolution (Appiah 2010) and the role that technology plays in it has been largely neglected. The second case (pills) was chosen because it is often discussed in the context of moral change (e.g. Swierstra 2013; Jaeggi 2018) and framed in revolutionary terms (the sexual revolution). We picked our third case (pork) to include a revolution that is arguably still in the making, thereby signalling the relevance of anticipatory – as opposed to merely historic – analysis for the topic. By contrast, our fourth case (ploughs) pertains to a rather distant technomoral revolution, although the consequences of this revolution are still with us today. Two further reasons

³Additionally, note that scholars working in the technomoral change paradigm typically emphasize the bidirectional nature of technology-morality interactions: technology shapes morality and morality shapes technology in turn. By contrast, the present study specifically looks at how technology shapes morality. We grant, however, that in technomoral revolutions both influences may be present (see fn. 15).

⁴Pinpointing society-level moral change is not easy; some of the significant moral shifts we identify are culturally specific; some of them remain contested to this day. Our terminology of (techno)moral revolutions is not meant to suggest that the episodes of change we discuss are ‘smooth’ or have been ‘completed’; we merely use the term to identify changes that are radical, such that the posterior moral outlook in a given society is decidedly different from the anterior state.

for choosing these four case-studies concern their diversity in terms of dynamics and domains. First, all four cases are characterized by an interplay between human agency, institutions, and other social structures, albeit with different emphases. Secondly, taken together the cases give a suggestion of the breadth of domains which can be involved in technomoral revolutions.

Two caveats should be made, before we move on. First, by emphasizing the role of technology in moral revolutions, we do not mean to deny the importance of other factors, let alone to advance technological determinism (to wit, the view that a society's technology determines its culture and social norms, and/or agents' beliefs and behaviour). Like Swierstra and other advocates of the technomoral change paradigm, we recognize that processes of societal change are incredibly complex, and that technology is never the sole determinant of moral change. Instead, we are dealing with multifactorial historical explanations, in which technology is but one factor, albeit one deserving particular attention. Rather than being the driver of moral change, technology may also serve an enabling role, generate critical mass to reach a tipping point, or act as a triggering cause. All of these are among the 'noteworthy roles' that interest us. We proceed on the hypothesis that 'technomoral revolutions' carves out an interesting category and have selected case-studies where at least *prima facie*, technology does have a noteworthy role to play. But we have selected these case-studies neither with a firm preconception of *what* this role amounts to, nor *how substantial* technology's influence in moral revolutions is. Instead, we approach our examples in a spirit of open inquiry, as test-cases that help to shed light on the general structure of technomoral revolutions, as well as potential limitations of the concept.⁵

Secondly, we do not aspire to take historians' place by making original historical claims, or by revealing novel causal connections. Indeed, we grant that from a historical point of view, our retellings may be regarded as incomplete and somewhat selective. Rather than contributing as historians, we contribute as philosophers of technology, who aim to conceptualize and clarify technology's role in moral revolutions. The four case-studies provide empirical input to foster this endeavour.

⁵We grant, too, that for some of the case-studies we will discuss the label of '(techno)moral revolution' can be disputed, and may ultimately be unsatisfactory. We reflect on some of the notion's merits and shortcomings in section 4.

3. Pistols, pills, pork and ploughs: four case-studies

3.1. Case-study 1: honour, pistols, and the demise of duelling

Our first case-study concerns a social shift that Appiah (2010) has framed in terms of a moral revolution: the demise of duelling in Britain by the mid-nineteenth century, which coincided with the decline of an aristocratic culture of honour. Duelling, as a way to resolve private conflicts and defend one's honour, was commonplace among aristocratic men in early-modern Europe (Parent 2009; Appiah 2010). Under an implicit honour code, duels were fought to protect one's reputation from dishonour brought upon it, for instance, by accusation of theft or insult. The effect of this social custom, some argued, was to ensure that gentlemen treated each other with due respect and courtesy and to enforce a basic level of equality amongst gentlemen (Appiah 2010, 33). Yet over the course of the nineteenth century, the institution fell into disfavour in many places, albeit at different moments in different countries. According to Appiah, part of what led to duelling's demise in Britain was that it had become disassociated from the concept of honour – duelling ceased to be a mechanism by which gentlemen could effectively defend their honour. Influenced by historian V.G. Kiernan, Appiah (2010, 49, 162) argues that this disassociation was facilitated by the aristocracy's declining status as a class and by the *embourgeoisement* of the duel: whereas originally the practice was largely restricted to the aristocracy, over time, members of the middle class, such as businessmen and tradesmen, also began to engage in duels.

We propose that one interesting aspect in this process of *embourgeoisement* – overlooked by Appiah – is the role that pistols played in it. Before making this argument, however, we should clarify why Appiah's qualification of a 'moral revolution' may be appropriate for what might appear to be a rather domain-specific change. On Appiah's telling, the demise of duelling was intricately connected with the changing conception of 'gentlemanly honour' in society. Conceptions of gentlemanly honour were partially comprised of normative beliefs about gentlemen's conduct in a specific set of circumstances, such as when they were threatened, or accused of dishonesty. In a 'culture of honor' or 'society with an honor code' such conduct was morally charged. Accordingly, duelling was a morally relevant practice, and the question of whether duelling was permissible or obligatory (and how it should be conducted) was an important issue of social morality. Notably, during the heyday of duelling, although many people offered moral arguments against duelling, the practice

continued (Appiah 2010). The disappearance of the practice, then, at minimum involved a shift in which the practice came to accord with the moral beliefs of those opposed to duelling; in addition, it is likely that some people at the time underwent a shift in their beliefs about its moral permissibility.

We want to suggest that technology – weaponry specifically – played a distinctive role in transforming duelling practice in several morally significant ways. It did so in combination with individual decisions and social factors. Most importantly, the introduction of a new kind of weaponry in duelling released the practice from the grips of the aristocracy, in a way that ultimately altered its significance for gentlemanly honour. For the better part of the 16th to 18th centuries, swords had been the weapon of choice in duels (Shoemaker 2002, 528). Duelling was an affair between nobles and aristocrats, who – unlike the broader populace – generally possessed swords and had obtained fencing training in their youth (Shoemaker 2002, 528). Yet over the eighteenth century pistols increasingly became the weapon of choice, for a number of reasons, including perceptions that pistol duels were fairer, and (some evidence suggests) a decline in fencing training amongst aristocrats (Shoemaker 2002, 528–529). This transformed the duel in several ways.

In sword duels, skill had been key: a small difference in skill could lead to a significant advantage for the better swordsman. Pistols did not require as much practice or skill as swordsmanship did, thus putting the duellists on a more equal footing. In fact, early pistols were so inaccurate that duellists would often miss, thereby decreasing the chances that duels resulted in fatal injuries. As the accuracy of pistol technology improved, additional norms and procedures were adopted that lowered the chances of fatality. One such norm was the discouragement of sights and rifling, use of which would have increased accuracy; another had to do with increasing the distance at which duellists should stand (Shoemaker 2002, 532–35). Somewhat surprisingly, then, with the introduction of the pistols and the social adjustments that followed in response, the chance of fatality went down (Shoemaker 2002).

The process by which the duel was conducted also changed. According to Shoemaker (2002), in the early 1700s, gentlemen often carried swords on them and if challenged could conduct a duel with little delay. By contrast, few carried pistols on them; pistols would need to be fetched before a duel could commence. Thus, by the late 1700s, when pistol duelling prevailed, there was typically a delay between duel challenge and duel execution, during which tempers could cool and friends might intervene

to resolve the conflict (Shoemaker 2002, 533). The act of duelling itself, too, changed as a result of substituting technologies. By custom, a sword duel might end (if not by death) by injury, first blood, or the disarming of an opponent (Shoemaker 2002, 530). The sword fight itself might be relatively continuous, without technology-induced moments of pause. By contrast, duelling by pistol, given the nature of technology at the time, involved a more discreet sequence of actions. After each party had fired, they would need to reload or acquire another loaded pistol. Like the sword duel, the pistol duel might end by death or injury, but a custom also quickly developed according to which duellists would agree before the fight on a fixed number of exchanges of fire. After that exchange, the duel would end even if no blood had been drawn (Shoemaker 2002, 534). Pistols also supplied duellists with a new way to demonstrate their courage and willingness to risk their life, while not endangering their opponent: having withstood the fire of their opponent, they could respond by firing their pistol in the air or declining to fire (*ibid.*). Hence, differences in the affordances of the technology involved enabled or encouraged changes to the practice

An artefact's affordances depend both on its physical properties (e.g. the amount of pressure required to fire a pistol; the heft of a sword) as well as contextual factors (including properties of the subjects that use the artefact, e.g. their lack of experience in using a pistol or sword; whether they own a pistol or sword). Affordances can thus be understood as relational properties that make, for certain subjects in certain circumstances, certain actions likely (Klenk 2021). Our suggestion is that the pistol contributed in a noteworthy way to the 'embourgeoisement' of the duel that Appiah describes, because in the context of the time, pistols afforded the possibility of duelling to the middle class in a way that swords had not.⁶ The pistol was more readily available than swords to people outside the aristocracy.⁷ Furthermore, when duelling by pistol rather than sword became common practice, duelling no longer required skills typically possessed only by aristocrats. These

⁶In taking on board the embourgeoisement theory for the demise of duelling we diverge from Shoemaker (2002), who rejects this thesis (544–545). Using data from London from 1660–1724 and 1775–1800, he questions the extent to which duelling became popular among non-aristocrats, observing that the vast majority of duellists in both periods were gentlemen. As he acknowledges, though, his data do show an increase in the proportion of non-gentlemen duellists between the two time periods. Shoemaker himself argues instead that the duel declined because of a shift in the conception of gentlemanly honour that required greater gentleness, sensitivity, emotional control, and other character traits in tension with the violence of duelling; and because alternative mechanisms for defending one's reputation, such as legal remedies and statements in newspapers, became more attractive (541).

⁷See Schwoerer (2016) on the use of guns amongst men of different classes in early modern England.

factors opened up duelling to participants from non-aristocratic backgrounds. The new weaponry, then, enabled the participation of novel actors in the practice of duelling. Increasing participation in the practice by non-aristocrats, however, contributed to the practice losing its functional role within a tradition of gentlemanly honour. Other factors also contributed, including, as Appiah argues, the rise of a popular press and cartoons that depicted duellists in a farcical way. In the end, Appiah suggests, duelling fell out of favour because it came to be viewed no longer as a respectable action by which one could protect one's honour, but rather as vulgar, ridiculous, or comical.

Our pistol-embourgeoisement thesis suggests that pistols contributed to the decline of duelling. Not by altering the mortality rate or other costs associated with duelling, but via a process in which the technology enabled a rising middle class to engage in the practice. This, in turn, helped change the practice's normative status. We add to this finding three further insights that the case-study of duelling brings to the fore and that, we suspect, might also apply to certain other instances of technomoral revolution. First, the case illustrates the interplay between technological change within a social practice and the norms governing the practice and serves as a reminder that technomoral revolutions are historically contingent. Technology did not dictate how the practice of duelling or customs of honour evolved. It did, however, introduce affordances and pressures which eventually contributed to the duel's dissociation from honour, the duel's demise, and a change in conceptions of honour. Secondly, technologies can influence the social status of a practice, and shifts in social status, in turn, can unleash powerful pressures to transform a practice. In this case a technology helped render a practice less elitist, in a way that eventually stripped the practice of its perceived value. Third, technology can destabilize entrenched morally significant practices, in this case by enabling the participation of novel actors to the practice. As we will point out in section 4, such destabilization can create opportunities for moral revolutions.

3.2. Case-study 2: contraceptive technology and radical changes in sexual morality

Our second case study concerns the radical changes in sexual morality that have occurred in the Western world over the course of the twentieth century, particularly since the 1960s. The transition that interests us here is a shift away from a relatively strict system of sexual morality, in which

sex outside of marriage is impermissible, the permissibility of sex is closely tied to reproduction, homosexuality is regarded with moral disdain, it is morally problematic (especially for women) to engage in sexual activities solely for the purpose of pleasure, and chastity, purity, and sexual modesty are important virtues (again, especially for women). Changes to sexual morality during this time period took place at different levels; they include changes in moral norms, public opinion, behaviour, institutions, and laws. Among other things, the post-revolutionary situation features higher rates of sex before marriage and a higher average number of sexual partners (Twenge, Sherman, and Wells 2015), increased acceptance of premarital sex,⁸ decrease in the salience of traditional sexual virtues, increased popularity of the idea that sexuality is to be celebrated, as well as the demoralization of homosexuality.⁹ The decoupling of sex and reproduction undermined arguments against homosexual relations based on the claim that the moral legitimacy of sex depends on the possibility of creating offspring.

While scholars have pointed to several explanatory factors to account for the sexual revolution, including increasing individualism and women's increasing participation in the workforce (e.g. van der Burg 2003; Twenge, Sherman, and Wells 2015; Martin 1996), some have argued that contraceptive technology – and especially the pill, which became available in the early 1960s – played a crucial role (Cook 2005).¹⁰ While in the early 1960s only around 30 million people worldwide were using contraceptive technologies, including condoms and sterilization, this number rose to about 900 million in the mid-1990s (Diczfalusy 2002, 3). We do not want to make the claim that the pill and other contraceptives instigated this change by themselves, or were the sole causal factors involved. Nonetheless, their causal import was substantial; the sexual revolution – in particular, the increased acceptance of heterosexual intercourse for nonreproductive purposes – would have been difficult to bring about

⁸Twenge, Sherman, and Wells (2015) report that in the early 1970s 29% of Americans judged premarital sex as “not wrong at all”; by the 2010s that figure was 55%. We realise that, from an emancipatory perspective, the latter rating might still strike some as rather low. Our point, however, is not to argue that this (or any other) revolution has led to uniform and uncontested changes in western societies. Instead, we merely observe that a significant change has occurred in sexual morality during the second half of the 20th Century.

⁹It is common to refer to the developments that started in the late 1960s and continued through the 1970s as ‘the sexual revolution’, but scholars have pointed out that there were actually two sexual revolutions, the first one taking place in the 1920s (Martin 1996, 105). At that time, radical changes occurred in the sexual norms of young people, and initial uses of the term ‘sexual revolution’ date back to that period (Martin 1996, 110).

¹⁰As Martin (1996) points out, scholars of the ‘first sexual revolution’ that took place in the 1920s, too, ascribe a crucial role to contraception as an instigator of change (e.g. Craig 1934; Schur 1964).

without contraceptive technologies. Consequently, it is useful to think of contraceptives as an *enabling technology* for the moral revolution, as they allowed for an effective decoupling of sex and reproduction. According to Cook (2005, 112), the innovation that modern contraception supplied was ‘the reliable control of fertility without repression of sexuality or major damage to women’s bodies’ – in contrast to e.g. abstinence and risky abortion methods.

Interestingly, for our purposes, the development of the contraceptive technologies that facilitated radical moral change was driven in part by activists and social movements pursuing a variety of social and moral goals, such as the goal of conferring on women the freedom to enjoy sex without risking procreation, the goal of lowering abortion rates, and the goal of shifting the moral paradigm regarding sexuality and gender roles (Martin 1996). The technological development of the pill, for instance, is intricately tied to the history of a social movement and its advocates, in particular Margaret Sanger. In 1921, Sanger started the American Birth Control League, which later became Planned Parenthood. She worked to provide public information on reproductive health and contraceptives, and sought to facilitate access to contraceptives. Furthermore, in the 1950s her organization along with philanthropist Katherine McCormick co-funded endocrinological research on what came to be known as ‘the pill’ (Reed 2014). This constitutes an example of morality influencing technological development: activists pursued moral goals by exerting influence on the development of contraceptive technologies.

Technology, we discern from this case, can serve as an instrument to enhance individual agency and to empower interest groups. In the sexual revolution it did just this. By severing the link between sex and pregnancy, contraceptives, and specifically the pill, which some argue was the first reliable contraceptive technology for women, enabled some of the changes that reformers hoped for. This also serves to emphasize, once again, that technology was not the sole cause of change. Instead, the pill was developed by interest groups actively rallying for change; using the new technology to their advantage, it became an instrument that empowered their movement.¹¹

¹¹We surmise that many readers will regard the ensuing sexual revolution as an episode of moral progress – but as noted, our characterization of (techno)moral revolutions does not commit us to any specific moral evaluation (it *does* commit us to making a judgement about what moral changes in a society count as ‘significant’). Additionally, it is worth noting that judged from an emancipatory moral outlook, the introduction of the contraceptive pill has also had certain downsides. For instance, the pill has been criticised for creating a situation in which the division of responsibility for contraception is asymmetrical, with women bearing in many cases the sole responsibility for it. In addition, the

The changes in sexual morality, then, exhibit several features in virtue of which they can be regarded as a technomoral revolution. The change in question was *radical* (van der Burg 2003, 14), involving shifts in attitude and behaviour for large parts of society, with a profound impact on many people's ways of life and self-understanding (Cook 2005). One might even say that in this case, an old paradigm of strict sexual morality was replaced by a new one, at least for a large part of society. Furthermore, contraceptive technology played an important role in facilitating this radical change. The separation of sexuality and procreation, enabled by the pill with its high reliability, was a key part of the revolution.

3.3. Case-study 3: meat replacements, artificial meat and attitudes towards (farm) animals

Our third case study concerns changing attitudes and behaviour towards animals, specifically in Western societies. Arguably, the West has come a long way since Descartes' *Discours de la méthode* (2008 [1637]), where he declared that animals are mere 'automatons', without rational or sentient capacities. During the seventeenth century, attitudes towards animals began to change from taking animals to be servants of man to the recognition that they feel pain and have emotions (Thomas 1996). Indeed, changing attitudes regarding the moral status of animals have been picked out as a clear example of moral progress (Jamieson 2002, 329; Buchanan and Powell 2018, 57). The substantial shift of attitudes is reflected, among other things, in criticisms of factory farming, the moralization of meat consumption, and the rise of vegetarianism and veganism.¹²

That said, the production and consumption of meat in Europe and Northern America have been steadily increasing since the 1960s (Ritchie and Roser 2017). Hence, we find ourselves in a Janus-faced situation characterized by increasing awareness of animal suffering on the one hand, and increased meat production on the other. Singer's (1981, 121) observation that '[t]he expansion of the moral circle to non-human

pill has negative side effects, including mood changes, putting on weight, nausea, and hypertension (Cooper, Patel, and Mahdy 2022). Moreover, women who take the pill have a higher risk of having a stroke (Roach et al. 2015).

¹²Identifying the precise contours of this shift, as well as technology's role in it, is a complex affair. In Europe, advocacy for the idea that animal welfare merits serious moral consideration goes back at least to the 1700s, and has gotten substantial impetus from the 1960s and 1970s onwards, when the idea of animal rights emerged (Garner and Okuleye 2021). Arguably, our circle of moral concern (cf. Singer 2011) has nowadays expanded to include several non-human animals.

animals is only just getting under way' is arguably as relevant as four decades ago.

Can the change of the moral status of animals, and their corresponding treatment, nevertheless be regarded as an – ongoing – (techno)moral revolution? The change does fulfil one of Baker's (2019) chief characteristics of a moral revolution: it involves an intentional effort to change a moral paradigm. The idea of animal rights emerged only half a century ago, and intentional activism, like animal rights campaigns, publications on animal rights (e.g., Regan 1982), as well as the coining of new concepts such as 'speciesism' (Ryder 1971; Singer 1979), certainly played a role in fuelling discussion about the moral status of animals (Garner and Okuleye 2021). Activists have sought to shift moral perception (cf. Pleasants 2018) from an anthropocentric moral paradigm that considers animals as mere means towards a paradigm that regards animal exploitation and killing as morally problematic. Nowadays, in the US, more than 62% of people think that animals should have some form of protection or rights and nearly a third of people even believe animals should have the same rights as people (Riffkin 2015). Moreover, laws and public institutions concerning the moral status and protection of animals have been – and continue to be – erected.¹³ Pain and suffering of animals have come to feature in the laws and professional guidelines of several legislative bodies. For example, in the European Union, research that involves animal experimentation is strictly regulated and informed by the so-called '3Rs' framework (Replace, Reduce, Refine), aimed at minimizing animal suffering (European Commission 2010). Another indicator of the moral shift is the emergence of organizations devoted to animal protection, like the World Organisation for Animal Health, which currently has 182 member states.¹⁴

Technology plays an important role on both sides of our Janus-faced attitudes vis-a-vis animals. Consider the visceral footage of animal suffering in mass meat and dairy production, often recorded during clandestine actions, which has been used to raise public awareness about the conditions of industrial animal farming. Emerging technologies, such as smartphones and social media, have enabled efforts to raise public awareness about and organize campaigns against factory farming. Technology

¹³In most European countries animal welfare rules are in place. For instance, in 2021 the UK adopted a bill recognizing vertebrate animal sentience, which includes providing incentives for farmers to improve the living conditions of chickens in battery cages (Department for Environment, Food & Rural Affairs 2021).

¹⁴See <https://www.oie.int/en/who-we-are/members/>, accessed 7 October 2021.

can serve to make things visible and thereby alter our moral perspective (Verbeek 2011), for instance because it helps to put a spotlight on stakeholders that were previously hidden from sight.

On the other hand, technology has also enabled the mass-production of animal products. In particular, the discovery of vitamins, antibiotics, and the widespread use of animal vaccines, have been major enablers of the current practices of factory farming (Kirchhelle 2018). Moreover, as Swierstra (2013, 209) has argued, technology not only has the power to make stakeholders visible, but also to render them invisible. This also applies to the case of factory animals, where the industrialization of farming technologies has helped to hide animal suffering from the public.

Technology could potentially also play a key role in how attitudes towards farm animals evolve in the future. One way in which it may do so is by creating alternatives to our current practices of food-production and consumption. As Pleasants (2010, 149) has argued and illustrated with reference to the abolition of slavery, efforts to change an institutionalized practice can be substantially aided by the emergence of ‘a plausible alternative to it that is already available, and which would not make [people] much worse off.’ In the case of slavery, he argues, that alternative was wage labour. In the case of factory farming, the production of plant-based meat alternatives, as well as the development of in vitro meat, may serve as such alternatives.¹⁵ It is the ability to point to such alternatives that lifts objections to the harmful practice ‘out of the realm of merely moralistic expression and into that of efficacious radical social criticism’ (Pleasants 2010, 176). Animal liberationists ‘are able to argue that a “cruelty free” lifestyle is not only a feasible option, but one which would be much better for the consumer’s health, world food distribution, and the environment’ (Pleasants 2010, 176).

Other more established and feasible alternatives to meat-consumption already exist, like vegetarianism and veganism.¹⁶ Yet, despite these alternatives, many meat-eaters have not made this switch to a meat-free diet. One explanation for their refusal to do so is a strong taste preference for meat and because meat-alternatives leave them dissatisfied in terms of taste and texture (Collier et al. 2021). Making in vitro-meat available can lead to a change in the morally significant practices of meat consumption and production by providing an option that satisfies some

¹⁵In so far as the developments of those alternatives to animal meat are driven by moral concerns, such as concerns about animal well-being and concerns about greenhouse gas emissions, this is an example of morality shaping technology.

¹⁶In India, for instance, there is a long tradition of vegetarianism.

people's preference and desire for meat. This does not mean that the availability of artificial meat will inevitably lead to a shift in these practices, yet it will make this shift more likely by making meatless alternatives more attractive.

We conclude that new alternatives can transform the decision problems and payoff structures one encounters in the moral environment, a theme we will pick up on in section 4. By creating viable alternatives to factory farming, technology might contribute to conditions in which it is possible to see animal suffering not as natural and indispensable, but as something that can and should be ended. At present, however, this moral perception is still far from universal – and technology is being used to foster the interests of both meat-eaters as well as their opponents. Firm predictions about how attitudes towards factory farming in Western societies will evolve may be premature, but if recent history provides any guidance, it is likely that technologies will play a significant role in their evolution.

3.4. Case-study 4: the plough and a divergence of gender norms

As the foregoing case-studies illustrate, technology can have a rapid and disruptive impact on moral and social norms and values. But apart from being rapid, technology's influence on morality can also be remarkably long lasting, as our fourth case-study shows.

In the fields of political economy and cultural anthropology, extensive research has been done on the influence of ploughing technology on moral systems, specifically with regard to gender norms and gender inequality (Boserup 1970; Alesina, Giuliano, and Nunn 2013, 2018). When societies transition from hunting and gathering or herding to agriculture there are two broad types of agriculture that they tend to adopt. The first is *shifting cultivation*: this is labour intensive cultivation using hoes and digging sticks, a type of cultivation that is generally relatively evenly divided between men and women. The second is *plough cultivation*: an equipment-intensive form of cultivation using human- or animal-driven ploughs to churn up the soil. This type of cultivation 'requires significant upper body strength, grip strength, and bursts of power', and is less compatible with childcare than shifting cultivation.¹⁷ Apparently as a result of these factors, in cultures that use plough

¹⁷Alesina et al. describe childcare as 'a task almost universally performed by women' across cultures (Alesina, Giuliano, and Nunn 2013, 475). This is backed by evidence that the majority of childcare is performed by women in the majority of cultures (Rohner and Rohner 1982).

cultivation farming is mainly a male activity, while women are disproportionately given domestic tasks (Alesina, Giuliano, and Nunn 2013, 470).¹⁸

Remarkably, which type of cultivation cultures used in the pre-industrial era is robustly correlated with present-day norms about gender roles and female participation in labour markets, politics, and the ownership of firms.¹⁹ Cultures which traditionally had plough cultivation have more inegalitarian gender norms and less female participation in activities outside the household than societies that have traditionally had shifting cultivation, when other factors are held constant. This does not imply that societies with traditional shifting cultivation nowadays do not have any inegalitarian gender norms. It *does* make it likely, however, that they have less inegalitarian gender norms than they would have had if they had adopted plough cultivation. This relationship between traditional plough cultivation and gender norms holds when controlling for many other factors that have an influence on gender norms and female participation outside the home, including GDP per capita, traditional types of land inheritance rules, the traditional intensity of agriculture in the area, family structure, religious background, *etc.*²⁰ The relationship between traditional plough cultivation and (a) female labour force participation, (b) female ownership of firms, and (c) female participation in national parliaments remains statistically significant and negative even when all the other factors considered in the analysis which could explain gender norms are considered simultaneously (Alesina, Giuliano, and Nunn 2013, 509–513, esp. Table VII). These effects are relatively small (as we should expect, given the numerous other factors that influence present day gender norms and gender inequality), but highly robust. This suggests that the traditional technology use has a continuing effect on gender norms even in industrial and post-industrial societies, shaping gender norms in a more inegalitarian direction.

¹⁸Alesina et al. use the term ‘culture’ to refer to ethnic groups based on language, some of which are distinguished from each other at the sub-national level (Alesina, Giuliano, and Nunn 2013, 485, fig 1). These ‘cultures’ are drawn from the *Ethnographic Atlas* (Alesina, Giuliano, and Nunn 2013, 482).

¹⁹Here ‘robust’ means that the relationships discovered in the data are not easily contaminated by atypical outlying observations, and that the relationships remain statistically significant when an alternative definition of plough-use is used, when different country samples are used, and when European and neo-European countries (the US, Canada, New Zealand, and Australia) are omitted from the analysis (Alesina, Giuliano, and Nunn 2013, 500–501).

²⁰For a full list of the variables that are controlled for in the analysis, see Alesina, Giuliano, and Nunn, especially table VIII (2013, 509–513). To provide further evidence for their causal claim that traditional plough cultivation is causing the effects on contemporary gender norms and inequality, Alesina et al. use instrumental variable analysis, using land plough suitability as the instrument (2013, 514–520). On instrumental variable analysis as a method and for an assessment of Alesina et al.’s use of the method, see Muthukrishna, Henrich, and Slingerland (2021, 728–729).

It appears, then, that the gendered division of labour in plough cultures contributes to the development of different norms about appropriate roles for women, which deny them economic and social agency outside of the confines of the home, and that these norms are long-lasting and have long-lasting effects. In the words of Morris what we see here is that 'The internal structures of families (...) changed beyond all recognition' (Morris 2015, 58). The type of farming technology that is used creates a *cultural niche* – a modified environment that alters which behaviours and norms are transmitted – which affects the extent to which inegalitarian gender norms develop.²¹ When ploughing is the dominant form of cultivation it is more efficient to divide labour across gender lines: having (mostly) men plough while (mostly) women attend to household tasks leads to a greater quantity of food. Thus plough agriculture is a niche in which norms promoting that men plough the fields and women work in the home will be more likely to persist than norms which recommend equal division of labour, because these former norms produce a greater food quantity.²² Once these inegalitarian gender norms exist they may lead to the development of institutions and practices which further encourage the persistence or development of inegalitarian gender norms (on this process, see O'Connor 2019, Ch. 5). For one thing, if ploughs systematically give men greater economic power, men are in a better position to acquire disproportionate political or decision-making power, in a way that can further entrench inegalitarian gender norms. As an example of how plough adoption can influence institutions, plough cultures tend to develop a marriage custom called *dowry marriage*, in which the bride's parents are required to pay a large sum to the groom's family upon marriage. Societies without the plough are more likely to develop *bride price marriage*, in which the pattern of payments is reversed. Dowry marriage in plough societies further reinforces the societal preference for sons over daughters and affects the amount of resources that families invest in their sons over their daughters, with the consequence that female mortality in such societies is higher than male mortality (Alesina, Giuliano, and Nunn 2018).

Can the changing gender norms, furthered by ploughing technology, be understood as a technomoral revolution? Our minimal definition, which understands moral revolutions in terms of radical, society-level

²¹On cultural niche construction, see Laland and O'Brien (2011), Boyd, Richerson, and Henrich (2011), and Henrich (2016). On the theory of cultural evolution in general see Richerson and Boyd (2005), Henrich, Boyd, and Richerson (2008), Henrich (2016), and Mesoudi (2016).

²²It need not always be the case that societies reach an efficient division of labour. Instead, it is a matter of likelihood: if a division is more efficient it is more likely to persist, to spread, and/or to be copied (Cohen 2001, 464).

moral change, implicitly suggests that there has to be an identifiable moral status quo (or paradigm) prior to the revolution, and a moral status quo afterwards that is recognizably different – otherwise we could not speak of moral *change*. In this respect the discussed case-study may fall short. A complicating factor in the plough case is that we do not have firm knowledge of the moral status quo before the adoption of the plough, because of the historical distance of this event.²³ We do not know whether the status quo in pre-plough societies consisted of relatively egalitarian hunter-gatherer norms (Wood and Eagly 2012, 63), or of herding norms that were already quite inegalitarian along gender lines. Given this uncertainty, we cannot tell whether the plough case represents a diachronic shift from paradigm A to paradigm B. In addition, while the variance in present-day gender norms and social outcomes between traditional plough and traditional shifting agriculture societies is robust and significant, it is nonetheless relatively small due to the myriad of factors that go into determining present-day gender norms at a country level.

That said, even if it is uncertain whether the effect of plough on moral norms constitutes a paradigm *shift*, it certainly constitutes an instance of long-term, technology-induced paradigm *divergence* – i.e. the synchronic divergence of paradigms A (with a greater level of gender equality, other factors held constant) and B (with a greater level of gender inequality, other factors held constant). Whether a society adopted shifting or plough cultivation has had a measurable effect on its moral paradigm regarding gender norms, and partly explains the societal moral divergence that we still see today. This case demonstrates that the effect of technological change on moral and social norms is not limited to causing rapid moral change. Technology can also have a long-term shaping effect on morality and (de)stabilize a broad set of moral practices and institutions in society. Hence, the case brings into focus the different kinds of causal relationship that can obtain between technology and morality – a topic that has thus far received little attention among scholars of technomoral change, and merits further scrutiny.

4. Five roles of technology in society-level moral change

We have been using the term ‘technomoral revolutions’ to pick out cases of society-level, radical moral change where technology plays a

²³Arguably, further complicating factors are that the changes we describe were not driven by dissidents (Baker 2019) and did not occur rapidly (Appiah 2010). Note, however, that neither of these conditions are part of our minimal definition of moral revolutions.

noteworthy causal role in bringing the change about. While the term has served as a useful heuristic, we also encountered occasional difficulties in conceptualizing certain society-level shifts as ‘revolutions’. At a conceptual level, then, a first lesson we draw from this inquiry is that a focus on revolutionary change does not exhaust instances of society-level moral transitions worthy of the attention of technomoral change scholars. Technomoral change scholars may want to cast their nets wider than moral revolutions alone; furthermore, inquiry may benefit from introducing more fine-grained conceptual distinctions between revolutions and disruptions of different kinds.

In this section we turn to some of the noteworthy roles of technology in society-level change. Drawing on the cases we have discussed, we highlight five such roles, which we regard as worthy of further theoretical reflection.

4.1. Transform action spaces for decisionmakers

Technologies create novel possibilities for agency and influence which actions are open to agents. We will use the term ‘action spaces’ to refer to the set of actions that is open to an agent at the time of decision-making. Action spaces have both a ‘mind’ and a ‘world’ component. On the one hand, technologies influence the beliefs, values, experiences, emotions, perceptions, and capacities of agents, thereby altering the likelihood that they will perceive and take advantage of affordances in their social environment. On the other hand, technologies alter the affordances by altering the material environment itself and, through looping-effects, the social environment. These mind and world components are thus both dependent on technological affordances.

Consider the duelling case. Prior to the incorporation of pistols into duelling practice, when duelling meant sword fighting, non-aristocrats were excluded from participation in the practice because they had not been trained to use swords and generally did not possess them. The rise of the practice of duelling by pistol made it possible for non-aristocrats, who were not capable of duelling by sword, to participate in duelling.

This transformation of action spaces can also be discerned in the contraception case. Prior to the development of safe and reliable contraception, individuals who could become pregnant did not have the possibility of engaging in potentially procreative intercourse with minimal risk of pregnancy. The general lesson that we take from this case is that

technology alters action spaces through new or changed affordances and constraints. The severing of a constraint imposed by biology enabled patterns of action that would previously have been improbable or impossible. Insofar as action concerns morally relevant practices, the transformation of action spaces engenders opportunities for moral change. Insofar as action spaces change drastically through technology and do so not only for a few decisionmakers, but for large groups, such change can amount to a technomoral revolution.

4.2. Alter payoff structures for decisionmakers

Technology can make actions more or less costly to perform, given an agent's values, by changing the nature of the action and what is required to perform it, or what is likely to follow from it. We can conceptualize this in terms of the (imagined) payoffs associated with available options, which change as a result of the technosocial environment changing. Here, 'payoffs' include anything the person values, ranging from economic benefits to honour and reputation to the welfare of animals. The case of duelling illustrates how a technology's incorporation into an existing practice can alter the payoffs or risks associated with the practice, by altering the associated probability of death or injury. The initial adoption of pistols for duelling appears to have resulted in a drop in the duel's mortality rate due to their inaccuracy; subsequent technological innovations increased pistol deadliness; still deadlier innovations like rifling and sights might have increased mortality even more, had Britain not developed norms to discourage their use (Shoemaker 2002, 532). Similarly, reliance on the plough rather than shifting agriculture appears to have altered the costs and benefits associated with the task of soil preparation for individuals of different genders.

Altering payoff structures may be an important mechanism by which technological change can contribute to moral revolutions. For instance, if a technological change raises the probability of harm associated with an action beyond some threshold that people are not willing to tolerate, or reduces the economic costs of an action that people previously considered exorbitant, these shifts may cause agents to question and re-evaluate their habits or usual decisions. Once again, when payoff structures change not only for a few individuals, but for social groups in their entirety, this re-evaluation can result in a technomoral revolution.

The alteration of *moral* payoff structures is a special case of this mechanism, which pertains to payoffs that are particularly moral in nature. For

instance, a group views some practice as morally wrong or at least not ideal, but its members believe that it would be too costly or difficult to act differently. In this kind of situation, a technological change that makes possible or reduces the costs of an alternative and morally superior (in the eye of the decision maker) course of action can result in a shift in practice, as people alter their actions to align them with their moral beliefs.

In other cases, factors like self-interest or background beliefs, such as the perception that there is no viable alternative, can even prevent people from *seeing* a practice as morally wrong. Such factors may prevent people from pondering the moral question to begin with, may influence the evidence they consider on the question and how they weight it, may lead them to view the current situation as natural and inevitable (see Jamieson 2017; Pleasants 2010), and so on.²⁴ As we have discussed, it is the hope of some people working to develop an alternative to factory-farmed meat that the availability of an attractive – tasty, affordable – alternative to traditional meat will prompt widespread changes in eating practices. In this pattern of moral change, we suggest that a technology can operate as a trigger, and the change may occur relatively quickly – particularly if there are activists or advocates for change, who spread awareness of the alternative when it becomes available and who bring the force of moral arguments to bear on people’s decisions in the newly altered context.²⁵

4.3. Destabilize entrenched norms

If our ‘pistol-embourgeoisement thesis’ is correct, the use of pistols in duelling made it possible for non-aristocrats to participate in the practice of duelling. But duelling was attractive to aristocrats precisely because it allowed them to procure respect from their peers; the custom only served this role if it was exclusive. The embourgeoisement of duelling

²⁴Psychological phenomena such as loss aversion (Kahneman and Tversky 1984; Kahneman, Knetsch, and Thaler 1991; Mrkva et al. 2020; Ruggeri et al. 2020), status-quo bias (Eidelman and Crandall 2012, 2014), and system justification motives (Jost 2019; Jost, Banaji, and Nosek 2004; Jost et al. 2019; Kay and Friesen 2011; Friesen et al. 2019) can all play a role in leading people to view the current status quo as natural or inevitable and to view possible changes as too costly to contemplate.

²⁵This relates to a point that has been made previously by philosophers of technology, that situations that may appear dilemmatic such as the choice between sexual abstinence or risk of pregnancy may be resolved through technological innovation (e.g. van den Hoven, Miller, and Pogge 2017). When the dilemma is particularly moral in nature, this phenomenon has been discussed as a situation of ‘moral overload’, which technology may help resolve (van den Hoven, Lokhorst, and van de Poel 2012).

undermined the value of the practice for aristocrats. Thus, the idea is that a technological change enabled a social change that reduced the value of the practice for the elite that had practiced it. Furthermore, if the elite no longer viewed the practice as a way to preserve honour, this presumably reduced its value for those in the middle class concerned with honour. It also meant that the protections the practice had received in virtue of being conducted by members of the aristocracy were lost.

In this particular case, we see a pattern in which one technology replaces another in an entrenched moral practice, and the technological substitution ultimately destabilizes the practice. This technology-induced destabilization is worth flagging as another noteworthy mechanism by which technological change can contribute to moral revolutions. It may be one route by which a technology can constitute a 'morally disruptive technology,' to use Baker's phrase (Baker 2019, 144; Wilson 2014). Technomoral disruption has also been associated with moral uncertainty (Baker 2013); it may be characterized as 'a situation in which the established collective moral norms associated with a set of practices are undermined through technological innovation, without new moral norms clearly emerging.' (Nickel 2020, 1). Technomoral disruption will not necessarily lead to the development of a fullblown technomoral revolution. Technomoral revolutions involve a marked status quo before and after. When there is an uncertain and still unstable state, the contours of the possible issuing moral change might be too vague to determine that a revolution has indeed occurred.

4.4. Generate moral niches

Technologies can influence processes of cultural – and moral – niche construction, in virtue of offering affordances for, or hindrances to, the development of moral systems. Plough technology created a cultural niche for inegalitarian gender norms, which subsequently gave rise to institutions that further entrenched and perpetuated unequal gender norms and unequal outcomes for men and women. The technology helped to shape a *moral niche*: a niche in which particular moral norms and institutions are likely to evolve and persist.²⁶ Given the importance of technology in shaping and sustaining this moral niche, we might call it a *technomoral niche*. In a technomoral niche, the human-modified environment, partially constituted by technology,

²⁶On moral niche construction, see Scott (2009), Dean (2014), Severini (2016).

influences the moral development of group-members, and influences the natural and cultural selective forces to which individual and group morality is subjected. The plough-based technomoral niche produced directional pressure that facilitated moral institutions of one kind (i.e. institutions entrenching gender inequality), while hindering the development of institutions of another kind (i.e. institutions entrenching relatively higher levels gender equality). By incorporating the plough into their way of life, groups did not only modify the probabilities of successful food acquisition. They also modified the environment in which individuals form their preferences, abilities, expectations, values, *etc.*, and eventually in some cases the possible actions available (whether by custom or other factors, such as physical ability) to group-members of different genders.

The case of duel by pistol illustrates how a new technology can destabilize a moral practice and contribute to the demise of a prevalent moral code. By contrast, the case of the plough illustrates how a technology can stabilize a new moral order, potentially over a long period of time. The idea is that the plough facilitated the adoption of one set of norms over others. We can imagine that when communities first began to use plough technologies, individuals and groups might have made sensible decisions, given their goals, about how to distribute work amongst individuals with varying strengths, weaknesses, and preferences. When a gendered pattern emerges in labour distribution, though, the pattern can easily become an entrenched social practice – maintained by mechanisms like gender-role-based norms, the tendency of children to imitate adults they consider similar to themselves (Henrich 2016, 44-46), the tailoring of technology to the people that already use it (see e.g. Weber 1997), and so on, in combination with the continuation of the incentive structure that prompted the decisions that produced the gendered pattern in the first place (i.e. higher probability of acquiring adequate food). Inasmuch as the affordances of the plough continued to incentivize the division of labour tasks by gender over the centuries, the technology helped stabilize a particular moral order over a long period of time – in this case, a moral order with very significant results for the rights, duties, and virtues allocated to different subgroups of people. As the niche was passed on to successive generations, an ever more intricate constellation of coherent norms emerged, some of which have been remarkably robust. Hence, the plough case shows how technologies can generate moral niches and lead to path-dependent trajectories of moral evolution.

4.5. Operate as instruments of empowerment and repression

Another noteworthy element of technomoral revolutions are the intentional actions of moral activists who use technology as part of their effort to advance a specific goal, such as the establishment of a novel moral paradigm (cf. Baker 2019). Such agents include moral dissidents and entrepreneurs, the defenders of an existing moral order, and (if the revolution succeeds) moral irredentists, who seek to restore a previous moral order.²⁷ One way in which this occurs is when moral dissidents intentionally attempt to influence technological development for the purpose of ultimately bringing about a radical moral change. The case of Sanger helping to encourage and fund research to develop the contraceptive pill is one instance where a moral dissident appears to have succeeded in advancing her cause by intentionally supporting technological innovation. Similarly, efforts to create plant-based or in-vitro meat may be understood as attempts to bring about a moral revolution via technological innovation, thereby solving moral dilemmas by technological means (cf. van den Hoven, Lokhorst, and van de Poel 2012).

This is not to say, though, that most attempts to use technology to facilitate moral change achieve the intended effect. In fact, such attempts may have additional, unintended impacts on morality. For instance, some have argued that the set of changes involved in the sexual revolution eventually paved the way for the increased acceptance of homosexuality that has occurred in the past few decades (Baker 2019; Borten 2002). The idea is that as sexuality and procreation were disentangled at least in part because of contraceptives, objections to homosexuality lost support.

Also, note that apart from serving as instruments of empowerment, technologies can serve as instruments of repression. The medical and industrial technologies used to subordinate farm animals are a case in point. Technologies often work at cross purposes: camera and sensor technology are used to police farms, thereby serving the aims of the farming industry to hide animal suffering, but cameras and recording devices are also used by animal activists, in an effort to make the hardships of factory farmed animals visible to the public. Whether the revolution will be televised does not only depend on the technology as such, but on whether (counter-)revolutionaries succeed in instrumentalizing it for their purposes.

²⁷The terminology of moral dissidents and irredentists comes from Baker (2019).

5. Conclusion and further research

In moral philosophy, moral revolutions are a topic of growing interest, but the role of technology in such revolutions has received little attention. In the philosophy of technology, technomoral change is an emerging research paradigm, but no specific attention has been given to revolutionary changes. In this article, we have begun the work of filling this lacuna by sketching the structure of technomoral revolutions. This structure, we find, is by no means uniform. There are various fundamental and encompassing ways in which technology can influence morality, some of which have only been of subsidiary interest to prior scholarship, but certainly merit further analysis.

Our outline is not meant to exhaust the ways in which technologies can contribute to society-level moral change. A fuller exploration of the mechanisms by which technology can influence such change is called for. Empirical investigations could help assess what the causal strengths of different types of technologies are, and the ways in which they interact with other change-inducing dynamics, such as human activism, economy, law, politics, and religion. Furthermore, the concept of 'technomoral revolution' itself might be broken down, by differentiating between technologies and revolutions of different sorts. We have only supplied a minimal definition of technomoral revolutions; the task of further fleshing out this concept remains to be undertaken. Finally, our preliminary findings have unearthed several concepts, such as 'technomoral niche construction' and 'moral payoff structures', that may serve as useful tools in future inquiry, and would benefit from being put on a more rigorous theoretical footing.

Technologies have contributed to major, radical, and long-lasting moral changes in our societies and lives. They will likely do so in the future. Whether the Fourth Industrial Revolution lives up to its promise, or whether we find ourselves amidst forces of technological disruption whose direction of change is more difficult to anticipate, remains to be seen. Come what may, identifying appropriate concepts and devising fruitful analytical tools to come to terms with the technomoral revolutions of the past, will help to prepare for the revolutions and disruptions that lie ahead.

Authors' contributions

All contributing authors were involved in discussing the paper's structure and deciding on the core case-studies. J.H. drafted a first version of the

paper's outline, abstract, section 2, and oversaw the completion of the manuscript. C.E. drafted a first version of the introduction and conclusion. C.A. drafted a first version of section 3.1. J.H. and S.S. drafted a first version of sections 3.2 and 3.3. L.F. substantially contributed to section 3.2. C.B. drafted a first version of section 3.4. E.O. drafted a first version of section 4. M.K. substantially contributed to section 4. We emphasize that the entire paper has been a collaborative effort, which emerged from joint readings and discussions. All authors have edited and approved the final manuscript.

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ORCID

J. K. G. Hopster  <http://orcid.org/0000-0001-9239-3048>

C. Arora  <http://orcid.org/0000-0003-4998-8390>

C. Blunden  <http://orcid.org/0000-0002-7027-2269>

C. Eriksen  <http://orcid.org/0000-0003-3080-8337>

L. E. Frank  <http://orcid.org/0000-0001-8659-2390>

J. S. Hermann  <http://orcid.org/0000-0002-3232-1656>

M. B. O. T. Klenk  <http://orcid.org/0000-0002-1483-0799>

E. R. H. O'Neill  <http://orcid.org/0000-0002-2794-498X>

S. Steinert  <http://orcid.org/0000-0001-8784-7607>

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