Yesterday's child: How gene editing for enhancement will produce obsolescence – and why it matters.

This is the PRE-PRESS version of a paper that appeared as:

Robert Sparrow (2019) Yesterday's Child: How Gene Editing for Enhancement Will Produce Obsolescence—and Why It Matters*, The American Journal of Bioethics, 19:7, 6-15, DOI: 10.1080/15265161.2019.1618943*

Please use that citation

Abstract: Despite the advent of CRISPR, gene editing for human enhancement remains well beyond our current technological capabilities. For the discussion about enhancing human beings to be worth having, then, we must assume that gene-editing technology will improve rapidly. However, rapid progress in the development and application of any technology comes at a price: obsolescence. If the genetic enhancements we can provide children get better and better each year, then the enhancements granted to children born in any given year will rapidly go out of date. Sooner or later, every modified child will find themselves to be "yesterday's child". The impacts of such obsolescence on our individual, social, and philosophical self-understanding constitute an under-explored set of considerations relevant to the ethics of genome editing.

Keywords: ethics, enhancement, human enhancement, genome editing, gene editing, genetic modification, obsolescence, CRISPR.

Yesterday's child: How gene editing for enhancement will produce obsolescence – and why it matters.

Introduction

The development of the CRISPR/Cas9 gene-editing system, alongside of other new molecular tools, has reinvigorated debate about the wisdom of genetically modifying human beings. One of the key figures in the scientific development of genome editing has openly advocated using these new technologies to enhance human beings by providing them with beyond-species-typical traits (See the remarks attributed to George Church in Regalado 2015). In this paper I develop a novel argument about the implications of genetic human enhancement that focuses on the consequences of technological progress in gene editing. Despite the advent of CRISPR, gene editing for human enhancement remains well beyond our current technological capabilities, mostly because of a lack of the requisite knowledge of the relation between genotype and phenotype in human beings. For the discussion about enhancing human beings to be worth having, then, we must assume that gene-editing technology will improve rapidly. However, rapid progress in the development and application of any technology comes at a price: obsolescence. If the genetic enhancements we can provide children get better and better each year, then the enhancements granted to children born in any given year will rapidly go out of date. Sooner or later, every modified child will find themselves to be "yesterday's child". The impacts of such genetic obsolescence on our individual, social, and philosophical self-understanding constitute an under-explored set of considerations relevant to the ethics of genome editing.[1] In particular, I will argue, the observation that genome editing will introduce

[1] I have discussed the implications of obsolescence for enhancement more generally in Sparrow (2015a). See also, Wolbring (2010). In this paper I focus on the case of genetic enhancement to the exclusion of other forms of

obsolescence into the human genome lends force to a line of thought developed most famously by the German philosopher Juergen Habermas (2003) that suggests that genetic human enhancement would blur the distinction between people and products.

I. Gene editing for human enhancement

Philosophers, scientists, and bioethicists have been writing about the ethics of genetic modification of human beings since the 1970s (Fletcher 1974, Jonas 1974, Ramsey 1970). Ever since the discovery of DNA people have speculated about the possibility of altering it in order to improve human beings. However, most of the philosophical literature on human genetic modification was produced after the development of recombinant DNA technology in the 1970s. Despite philosophers' enthusiasm for genetically modifying human beings (Bostrom 2003, Green 2007, Harris 2007, 2015, Powell and Buchanan 2011, Savulescu 2016), their discussions of the ethics of doing so have been well in advance of the science. Until recently the project of genetically modifying animals — let alone humans — foundered on two difficulties. First, the available techniques for introducing new DNA into the genome did not allow scientists to control the point at which the new sequence was inserted, which in turn made it exceedingly difficult to be confident about the phenotypic effects of any modification (Chan et al. 2015, de Melo-Martín 2016, 49-50). A second problem, the extent of which was somewhat obscured by the first, is that our knowledge of the genetic determinants of desirable phenotypes in *Homo sapiens* is extremely limited (de Melo-Martín 2016, 146-151, Lander 2015). Consequently, it would have taken a very bold — indeed arguably foolish — parent to genetically modify their child. No matter how successful an analogous genetic modification has proved in animal models, first use in humans would necessarily be experimental.

Recently, however, one of these problems has been (mostly) overcome. The CRISPR/Cas9 genome-editing system allows scientists to control the point at which new sequences of DNA

enhancement and especially on the implications of genetic obsolescence for our understanding of what it means to be human.

are inserted into the genome of the target organism (Cong et al. 2013, Hsu, Lander, and Zhang 2014, Jinek et al. 2012, Mali et al. 2013).[2] While, as I will discuss further below, we are still some way from being able to use CRISPR to safely genetically modify human beings, this new technology renders it a much more realistic possibility.

Although the medical need for it is likely to be small (Sparrow 2015b), genome editing might be used for therapeutic purposes, to alter genes associated with genetic diseases or impairments (Gyngell and Savulescu 2016). However, most of the philosophical, and much of the popular and scientific, interest in genetic modification of human beings has concerned the possibility of *enhancing* human beings by altering their DNA (Church and Regis 2012, Green 2007, Regalado 2015, Savulescu 2016, Silver 1999, Stock 2003) and this is also the focus of my own discussion.[3] Genetic therapy ends when normal functioning is achieved and so effective genetic therapies will not generate obsolescence in the fashion that interests me here.[4]

The definition of enhancement remains a vexed question in the literature on human enhancement. At the most basic level, to enhance something is to make it better (Harris 2007, 1-3, 9, 185, Savulescu 2006), but this minimal motion fails to distinguish enhancement from therapy (Parens 1998, Resnik 2000). Those who, like myself (Sparrow 2010b), want to distinguish enhancement from therapy have proposed various places at which a line between therapy and enhancement might be drawn. An intervention might only count as an enhancement if it increased a welfare-promoting character trait: beyond what is normal for that particular individual; beyond what is normal for that particular individual and beyond what is species-typical for human beings of the relevant reference class (Boorse 1975, 1977, Daniels

[2] Although note that there remains some controversy about the extent to which CRISPR/Cas9 generates "off-target effects" (Knoepfler 2017, Liang et al. 2015, Ma et al. 2017, Scott and Zhang 2017) as well as the significance of such effects for the ethics of the use of the technology (Compare, for instance, Savulescu et al. (2015) with Lanphier et al. (2015)).

[3] As I discuss further below, my willingness to engage with this literature should not be read to imply that I myself believe that enhancement is a realistic possibility *given the current state of our understanding of genetics*.

[4] *Qua* therapy, a particular therapy may well be rendered obsolete by new techniques to secure or restore health. Nevertheless, the result achieved by a successful therapy — health — is not threatened with obsolescence by the development of better therapies.

1985, Sparrow 2010); beyond what is normal for that particular individual and beyond the *normal* human *range*; or, beyond the *maximum* of the species range (Juengst and Moseley 2016). However, on any of these definitions, further enhancement is always possible, which, as I shall discuss further below, means that as long as progress in enhancement technology continues, each and every set of enhancements will eventually be rendered obsolete.[5]

Genome editing can be used to modify somatic cells in the body of an adult organism or to modify cells in the early stage embryo. Editing the embryo has tremendous advantages compared to the alternative of genetically modifying somatic cells. Whereas somatic cell gene editing can only directly alter the functioning of the cells into which the new gene enters, modifications made to the cells in the early stage embryo have the potential to effect large changes in the organism's phenotype (Ishii 2015). Meaningful human enhancement is likely to require editing human embryos. Thus, for the purposes of this paper, when I refer to "genome editing" I mean editing of the DNA in the cells of the early stage human embryo — that is to say, with *germline* gene editing, although the fact that the enhancements will be heritable plays little role in the discussion that follows.

II. Becoming obsolete

Both philosophers and scientists are now openly advocating the genetic enhancement of human beings via genome editing (de Araujo 2017, Regalado 2015, Savulescu 2016, Veit 2018). Yet it remains the case that there are significant barriers, both theoretical and practical, to achieving this goal. Despite recent progress in genomics, the genetic determinants of the phenotypic traits that people are likely to want to enhance, for example, life expectancy, IQ, athletic performance, or appearance, remain poorly understood (Callaway 2014, de Melo-Martín 2016, 146-151, Doudna and Sternberg 2017, Nuffield Council on Bioethics 2016, 10,

[5] There are undoubtedly limits on the level of functioning that might be achieved by a biological organism in any given dimension and thus the extent to which particular traits may be "enhanced". Nevertheless it seems likely that no matter how enhanced an embryo was, further enhancements in some dimension or other would remain possible. In any case, if any ultimate limit on enhancement exists, we are unlikely to approach it for many decades.

Passarino, De Rango, and Montesanto 2016). What we do know is that these traits are influenced by multiple genes, as well as by environmental factors, in a complex web of interactions. Enhancing such traits will therefore most likely require precisely targeted changes to the genome at multiple locations. Moreover, even if we did have a good sense of the genes we would like to alter in order to achieve some phenotypic change, the amount of time required to determine whether a particular genetic modification of a human being has achieved the desired result remains a significant practical barrier to the development and application of this technology.

For these reasons, genetic enhancement of human beings remains a hypothetical project, which might, perhaps, be undertaken in the future. In order for it to be practicable, then, significant progress, in genomics and in molecular and developmental biology, as well as in relevant technologies, would need to occur (Knoepfler 2017, Lander 2015, Ormond et al. 2017, Savulescu 2016, National Academies of Sciences, Engineering, and Medicine 2017, 159). Indeed, for enhancement to become viable in the next couple of decades, this progress would need to be relatively rapid. Discussions of the ethics of genetic enhancement therefore rely on a submerged premise about the likelihood of rapid scientific and technological progress in this area in order to establish that this is an important discussion to be having now. For the purpose of this paper, I want to accept this premise in order to draw out some of its surprising implications.[6]

The intellectual commitments that typically motivate advocates of enhancement should also motivate them to support, and even to strive to ensure, rapid progress in enhancement technologies (Harris 2007, 184-188). Such progress, should it occur, will come at a price: obsolescence. If the genetic enhancements available to parents to choose for their children

[6] Just how plausible this assumption is, is another question. On the one hand, for the most part, scientific and technological progress occurs gradually, which suggests that it will be many decades still until meaningful genetic human enhancement is possible, if it ever become possible. On the other hand, as devotees of "the law of accelerating returns" like to emphasize, because scientific and technological progress relies on the results of previous investigations it has a tendency to accelerate (Kurzweil 2005). Moreover, there are more scientists working today than ever before. I am personally inclined to be skeptical about claims about *exponential* growth in the rate of technological progress but will, for the sake of the argument that follows, allow the premise that rapid progress will occur in order to engage in "immanent critique" of the project of genetic human enhancement.

improve every year, then the enhancements provided to children in any given year will quickly become obsolete. The children who are conceived in 2035, for instance, will be born with significantly better enhancements then the children conceived in 2030. And children conceived in 2040 will have better enhancements still. Each generation's enhancements will be rendered obsolete by the next's.

With other forms of enhancement, one might simply update or replace one's enhancements when better enhancements became available. However, because effective genetic enhancement of human functioning requires intervention at the embryonic stage, individuals may only be enhanced with genetic technologies once and they will not be able to change or update their genetic enhancements. Progress in the technology of genetic enhancement will therefore render the genetic enhancements of people born in previous years obsolete.

III. Observations about obsolescence

To be obsolete is, according to the OED, to be "no longer produced or used: out of date" (Pearsall 2002, 983). Thus, as I have already observed, things become obsolete as a result of progress. In order for change to count as progress, it must represent movement towards some goal or at least along some dimension of desirability: only things that become better can become obsolete. Obsolescence, then, requires a ranking. However, not every ranking implies that the thing ranked worse is thereby obsolete. Obsolescence assumes teleology. Moreover, as the definition above suggests, obsolescence affects things that are *produced* or *used*. Technological progress is the primary source of obsolescence. Cultural change may render things "old fashioned" but falls short of rendering them "obsolete".

To have obsolete genes, then, would not just be to have different genes or even "bad genes" but would rather involve being marked by teleology in a certain way. Indeed, obsolete genes would once have been considered good: before technological progress rendered them obsolete they were desirable and were inserted because they were the best genes then

available. Nevertheless, genes that are obsolete are, by definition, worse than those available today and their being worse is indicated by their place in a temporal progression towards better and better "enhancements". Those who have access to enhancement no longer choose them because better genes are now available. Thus, obsolete genes are not just "different" genes but are in, an important sense, "rejected genes".[7]

It might be objected that each of us is already involved in two processes that generate obsolescence at least to some degree. First, we age, so that in our advanced years we may not be able to do the things that we could do when we were younger. Second, cultural change, especially around use of technology, means that younger people often have skills and cultural competencies that older people do not. Thus — it might be argued — even if progress in genetic enhancement technology would generate obsolescence, this dynamic would not raise any new issues.

Yet to be old is not the same as being obsolete. Ageing is a natural process, and a ubiquitous one, and, as a consequence, is imbued with a set of meanings that are orthogonal to the essentially technological dynamics that structure obsolescence. This is not to imply that modern societies deal well with the phenomenon of ageing or that people do not often find themselves marginalized and socially excluded as they age. Nevertheless, in the absence of genetic enhancement, generational differences involve no difference in kind: everyone will age, and age in the same way. Finally, the ageing process is relatively slow one such that it does not rule out the possibility that, for much of their lives, older people have the same mental and physical capacities as younger people.

By contrast, insofar as we increasingly think of cultural change as being driven by technological change and sharing the same dynamic of progress, it *is* appropriate to speak of

[7] Again, it is necessary to emphasize that the fact that we might prefer gene "A" to gene "B" is not sufficient to establish that gene B is obsolete — this would only be the case if A is understood to be superior to B by virtue of being the product of technological progress. Importantly, this means that obsolescence is not the appropriate framework through which to understand natural genetic differences. In particular, genes associated with impairments are located in relation to an idea of health rather than an idea of progress: this will remain true even if, as the result of the development of effective gene therapies, individuals are no longer born with genes associated with particular impairments.

people's "skill sets" becoming obsolete. Moreover, if technological change is rapid enough, this process of obsolescence of skills may produce some of the same social consequences as obsolescence driven by enhancement (Scheiber 2014). Nevertheless, skill sets differ from genes in three important ways. In theory, at least, skill sets can be updated through education or retraining whereas genes may not be. Skill sets also tend to be domain specific so that even when they do become obsolete people remain contemporary in other aspects of their lives. For both these reasons, third, we also tend to think of skill sets as less integral to a person than their genes. Consequently, obsolescence of the genome may raise issues that are not raised by obsolescence of skill sets.

What this discussion does reveal, however, is that the extent and importance of the issues I discuss below is at least in part a function of the *rate* of progress in genetic enhancement technologies (Sparrow 2015a, 234-235). If these technologies develop slowly, any obsolescence the improvement generates may be assimilated to these more familiar phenomena. However, rapid progress will generate more distinctive issues. As I've already observed, moreover, *without* rapid progress in enhancement technologies genetic enhancement is unlikely to happen for the next several decades.

As I have argued elsewhere, rapid progress in technologies of genetic enhancement would place parents in a difficult position: it would never be the right moment to conceive children because waiting would always allow one to provide one's children with better genes (Sparrow 2015a). I have also suggested that rapid technological progress might bring about dramatic social consequences by radically reducing the amount of time in which people are capable of full social and political participation (Sparrow 2015a). However, while I will say a little bit about the social consequences of obsolescence below, neither of these issues is my primary concern here: instead I want to focus on the implications of genetic obsolescence for the modified person and for our understanding of what it means to be human.

IV. Feeling obsolete

How would it feel to be yesterday's child? What would it be like to think of oneself as obsolete? Until sufficient numbers of people have been genetically enhanced and their enhancements have become obsolete, attempts to answer these questions are inevitably speculative. Ultimately, the impacts of obsolescence for enhanced individuals is an empirical matter and will need to be settled using good social science research methods once a large enough group of modified — and then obsolete — individuals exist. Nevertheless, in so far as we will need to consider the impacts of obsolescence for individuals before we can determine the ethics of genome editing — and thus before we have access to empirical evidence — we will need to speculate about these.[8]

If progress in genetic enhancement is rapid enough, the genes of enhanced children will be obsolete by the time they are born, with those embryos being genetically modified at the time of the child's birth already receiving more powerful enhancements. Otherwise, in the context of rapid progress in enhancement technologies, individuals' genes may be rendered obsolete while they are still children, or perhaps young adults. Given that individuals are likely to "grow up with" obsolescence, one imagines that many of them will, at least to some extent, get used to it. People have a remarkable capacity to adjust themselves to their circumstances, especially when they cannot change them. While some people do seem to hang onto regrets and/or resentments about the circumstances of their births for their whole lives, many people do not.

On the other hand, as they get older, people are likely to be reminded of their obsolete genes when they encounter younger people with better enhancements. These interactions may make it harder to remain sanguine about obsolescence. It's also true, of course, that yesterday's child will always be "better" than "last year's child" and so people will have an opportunity to feel superior when they meet people who are older than them, whose enhancements will be even more obsolete. However, there is some evidence that people tend to find the experience of being socially inferior to other people more distressing than they find

[8] We might gain some insight by investigating the experiences of those persons whose skill sets have been rendered obsolete by technological progress. However, because, as I argued above, genetic obsolescence is likely to differ from obsolescence of skill sets in a number of ways, such investigations are of limited relevance only in this context.

the experience of being socially superior to people uplifting (Card et al. 2012, Kolbert 2018, Lin and Kulik 2002) and if that's true, then, in general, obsolescence will impact negatively on welfare. The impact of obsolescence on psychological well-being is also therefore likely to differ across the course of the lifespan: when people are young they will mostly meet people with worse enhancements than them; as they age, they will increasingly encounter people with superior enhancements. For this reason, the phenomenon of obsolescence seems likely to make the experience of ageing significantly more distressing. Finally, while a discourse of "different but equal" has been mobilized, with some — limited — success by (some) people with disabilities (Garland-Thomson 2019, Swain and French 2000), genetic differences that result from progressive improvements in enhancement technology will be difficult to represent as anything other than comparative. People whose enhancements have become obsolete may struggle to think of their outmoded and outdated genes as anything other than worse than the genes of people born after them.

V. Being seen as obsolete

As I have already intimated, the individual experience of having obsolete genes will be shaped, to a significant degree by the reactions of other people when they encounter "yesterday's child." When thinking about the social implications of obsolescence we should distinguish between its impact on the attitudes of parents, employers, and "others". Parents will be the people choosing enhancements for their children and the attitudes of parents towards their children typically play a significant role in the development of the child's psychology. Employers have the power to grant jobs and set wages. The attitudes of other people may also have implications for the well-being of people with obsolete genes. Again, my discussion is necessarily speculative but can draw upon relevant analogies.

How will parents feel about children who have become obsolete? Critics of enhancement have previously highlighted the way in which the pursuit of enhancement turns children into projects of their parents (Habermas 2003, Sandel 2007). In order to enhance their children, parents must settle — to their own satisfaction at least — the question of what a good life for

human being consists in, and then choose particular traits to alter in order to increase their child's chance of flourishing in accordance with this conception of the good (Sparrow 2011a). Where the means of enhancement is genetic, this means that the child's genes will be shaped by the decisions of the parents. What paying attention to the phenomenon of obsolescence adds to our understanding of the relation established between parents and their children by genetic enhancement is that parents' projects will always, in a sense, fail. As enhancement technologies improve, the parents' own values will imply that their child is inferior to children born subsequently, with better enhancements. Destructive "option regret" is a real danger. Of course, it seems likely that parents will still love their children. Perhaps they will even love them "for who they are", with a love untempered by comparisons with other children. Nevertheless, as Sandel (2007, 49-51) has observed, when parenting involves enhancement there is a strong tension between the love that "accepts" and the love that "transforms". The worry is that progress in genetic enhancement will mean that whenever parents engage with their desire to better their child they will also experience disappointment driven by comparison with the capacities of children born after their own child. Where this occurs, it strains credulity to think that children will not become aware that they are a disappointment to their parents.

By comparison, it is relatively straightforward to anticipate the responses of employers towards people with obsolete genes. While enhancement technology continues to improve, young people will be highly desirable employees for a few short years before a new generation, with better enhancements, enters the job market. The older an individual is, though, the less likely employers will be interested in employing them: jobs will become scarcer and wages lower. Eventually people with obsolete enhancements will find themselves effectively excluded from participation at the forefront of social and economic life, which presumes capacities that people with obsolete genes do not have.[9]

[9] A similar dynamic already operates in areas of the economy characterized by rapid progress such as computer science or biotech. In these industries, employees are at risk of discovering that their skill sets are obsolete by the time they are in their mid-30s. However, rapid progress in genetic enhancement would greatly exacerbate this phenomenon. While people can work to maintain and update their skill sets, they will not be able to update their genes.

What about the broader society? How will people in general respond to those with obsolete genes? Answering this question is complicated by the fact that, once enhancement becomes widely available, most people will, as they age, themselves come to have obsolete genes. Even so, it seems likely that the same cultural dynamics that will motivate enhancement — the desire to be better — will condemn those who have become obsolete. People's responses to each other will be shaped by the dates of their enhancements and so date of enhancement will become a new axis of social stratification. One might, nevertheless, hope that judging people to have inferior genes will be compatible with accepting that they are one's moral and political equals. For instance, it is often suggested by advocates of genetic testing (or screening) for genes associated with — what they hold to be — deleterious conditions that we can distinguish between our attitudes towards a genetic condition and our attitudes towards the people who are affected by that condition (Glover 2006, 28). However, this distinction is likely to be much harder to maintain in the face of genetic differences that result from obsolescence because obsolescence places generations in a relationship of succession that implies that each generation — and not just their genes — is "more enhanced" and therefore better than the next.

At the very least, then, the phenomenon of obsolescence seems likely to further exacerbate contemporary society' orientation towards youth as well as its lack of respect — bordering on contempt — for the elderly. It also seems likely that individuals whose genes were subject to obsolescence would experience a lifelong decline in income and social status relieved only by the knowledge that older people are even worse off. Finally, it is possible that the phenomenon of obsolescence will be corrosive of egalitarian intuitions in ethics and politics.

VI. Being obsolete

I have been engaged in speculation about a set of matters that are essentially empirical. To fully understand the psychological and social impact of having obsolete genes we would need to wait until a significant number of people had been enhanced and then become obsolete. In this section I want to focus on the ontological — rather than the psychological or social —

consequences of obsolescence. Indeed, part of my purpose in discussing the psychological and social consequences of obsolescence has been to clearly distinguish these from the ontological implications of obsolescence.

What I am calling the "ontological" consequences of obsolescence concern its implications for our understanding of human nature. What would it *mean* for someone to be yesterday's child? More generally, what would it mean to be human when human beings were marked by temporality of the sort that characterizes obsolescence?

Critics of human genetic modification have long worried that it risks turning people into products (Jonas 1974, Lewis 2015). Perhaps the most well-developed, and certainly the most discussed, contemporary version of this criticism is developed by the German philosopher Juergen Habermas (2003) in his book *The Future of Human Nature*. In that book, Habermas argues that genetic enhancement would blur the distinction between "the born" and "the made" by rendering the genomes of each generation a function of the decisions of their parents. The project of genetic enhancement requires that designers treat human embryos as systems to be manipulated and, thus, to adopt an "instrumental" or "technical" mode of relation to the future person. In this, he argues, it is to be distinguished from parenting, which — although it may have its instrumental moments — is regulated by a communicative relation to the child as a future member of the kingdom of ends (Malmqvist 2007). Habermas also claims that the transformation wrought by enhancement would be detrimental to human freedom insofar as, he suggests, understanding ourselves — and each other — as free and equal agents requires that our genomes not reflect the decisions of third parties (Prusak 2005). However, my concern is primarily with the first claim: that genetic enhancement would result in a transformation of human nature such that human beings would become "products": a full evaluation of the implications of this transformation must await another occasion.

The observation that progress in genetic enhancement technologies will render genomes obsolete lends force to this intuition in a number of inter-related ways.

First, the introduction of a dynamic of obsolescence into the human genome through the initial application of an effective technology of genetic human enhancement will constitute a decisive rupture in the history of human nature. Prior to this moment, every generation of human beings is of the same kind. After it, human beings – or at least their genomes — will be the sort of things that can become obsolete and generations will be ordered according to the extent of their enhancement. While the existence of this rupture doesn't itself necessarily imply that people will become products as a result of enhancement, it does draw our attention to the radical nature of the transformation initiated by the advent of genetic enhancement and to the need for a new account of our own relation to our genomes after this date.

Second, enhancement imposes a mode of evaluation on human beings that tends to reduce them to their ranking in a single dimension. This is so even though (presumably) different individuals will be enhanced in different dimensions: some may have enhanced intelligence, others enhanced longevity, still others enhanced artistic capacities, et cetera. However, even if the relative value of different sorts of enhancements is incommensurable, progress in enhancement implies that each *generation* is better than the last. People with enhanced IQs have still higher IQs, those with enhanced longevity even longer lifespans, those with enhanced creativity are more creative, et cetera. By identifying these as superior *enhancements*, we imply that they all have something in common, and thus that it is possible to rank human beings across generations.

Third — and relatedly — because progress requires a goal, progress in enhancement implies that human beings have a function or goal that enhancements improve or advance. The teleological nature of enhancement imputes a teleology to human life and, thus, to human beings. Again, this dynamic replaces an acknowledgement of the complexity of human life and the diversity of human ends with an estimation of the extent to which enhanced (and other) individuals are likely to achieve some determinate goal, conceived of as singular, if abstract (Garland-Thomson 2019). While, in theory, insisting that all human beings share an interest in achieving "flourishing", "freedom", or "well-being" need not detract from our recognizing that these goods may be realized in a plurality of ways, in practice a program of genetic engineering

intended to enhance our capacity to achieve these goods will, almost inevitably, substitute an ever a smaller number of proxies in order to assess progress in enhancement, which in time will converge on a single if abstract measure of enhancement, which in turn is highly likely to corrode our sense of the diversity of human ends.

Fourth, the phenomenon of obsolescence highlights the way in which enhancement subsumes human beings under an essentially technological dynamic that treats them as things to be improved upon. In the Kantian tradition in which Habermas is writing, people *are* ends or *choose* ends, while things *have* ends that people determine for them (I owe this formulation to Erik Malmqvist, *pers comm*). Obsolescence is something that happens to things not people, and thus by rendering individuals obsolete, genetic enhancement would reduce the gap between people and products.

Finally, the fact that the genes with which children are provided will become obsolete will itself become an important feature of the environment in which the children will develop. Anticipating obsolescence will therefore become an important consideration in the design process. As I noted earlier, one of Habermas's central concerns is the way in which the project design will involve a technological or instrumental mode of relationship with the embryo and, by implication, the future person. In requiring designers to respond to the properties that the embryo possesses by virtue of its nature as product, the phenomenon of obsolescence redoubles and intensifies the essentially technological mode of relationship that the designer must adopt to the designed in the course of trying to enhance them.

For all these reasons, introducing the possibility of obsolescence into the human genome would have dramatic implications for our self-understanding and for relations between persons. Enhancement would restructure the relations between generations, impose an implicit teleology on human life, and intensify the instrumental relationship between designers and the designed that Habermas has previously identified as corrosive of our sense of ourselves as the origins of our own life projects and thus as members of the kingdom of ends. Perhaps most fundamentally, by rendering human beings subject to obsolescence, enhancement would transform our understanding of what it means to be human such that we would come to

understand ourselves as — indeed, in an important sense to *be* — manufactured things to be improved upon in future iterations.[10]

VII. The price of progress

I have not attempted any "all things considered" evaluation here of the benefits (or costs) of genetic enhancement. There are obviously many relevant ethical considerations beyond those I have discussed here, some of which I have discussed elsewhere (Sparrow 2011b, 2012). Nor, for reasons of space, have I said anything here about the possible implications of relatively slow and incremental improvement in the enhancement technologies, other than to note that should we conclude that the technologies required for human genetic enhancement are unlikely to develop rapidly then there will be little, if any, urgency to the debate about the ethics of human enhancement via genome editing.

It also has to be observed that the conclusion that we should reject technological change because it would produce obsolescence is necessarily somewhat quixotic: the fact that a technology might get better is held to count against it! Nevertheless, obsolescence is, in a very real sense, the price of progress and it would be foolish to ignore this fact, especially when it is people who will be made obsolete by progress in genetic enhancement technology. Moreover, importantly, *every* human being will eventually discover her-or-his-self to be "yesterday's child", if even a small number of people pursue genetic enhancement. Once enhancement begins, the genomes of unenhanced persons will become obsolete. If this transformation is psychologically, socially, or ontologically significant – and especially if it is the latter – then the

[10] It might be objected — as it has been objected to Habermas's writings on enhancement — that my discussion in this section trades on, and is complicit with, a false genetic determinism. People are more than their genes and thus, even if, as I have suggested, particular genes will be made obsolete by enhancement, it would be a mistake to conclude that "people" would thereby be made obsolete. I certainly do not wish to endorse genetic determinism. However, what thinking about the relationship between enhancement and obsolescence reveals is the way in which rapid progress in enhancement technologies would render us, at the level of type rather than of token, akin to the other manufactured items we see around us. Even though individuals will continue to possess – and to determine – their own ends, they will also become the type of things that are subject to obsolescence. That this new self-conception is properly tendentious does not unsettle my claim that it is an inevitable consequence of surrendering the human genome to the dynamics of technological progress.

interests of unenhanced humans in not being subject to these consequences should loom large in any reckoning of the costs and benefits of this project.

Against these considerations, stand the expansion of human powers and the satisfaction of human desires that might be achieved by genetic human enhancement. Should it occur, rapid progress in enhancement technologies may be expected to produce dramatic changes in individuals capacities and, consequently, in their ability to realize various human (or even, allegedly, post-human!) goods (Bostrom 2003; Buchanan 2011).

The balance of these — and other — considerations remains to be determined. Recognizing that the rapid technological progress necessary to secure enhancement also has its price, and understanding the nature of the social, psychological, and ontological, implications of being "yesterday's child", are, I believe, necessary first steps towards this larger task.

Acknowledgements

This research was supported by the Australian Government through the Australian Research Council's Discovery Projects funding scheme (project DP170100919) and the Australian Research Council Centre of Excellence for Electromaterials Science (project CE140100012). The views expressed herein are those of the authors and are not necessarily those of the Australian Government or Australian Research Council. An early version of this paper was presented at the Chinese University of Hong Kong and I would like to thank Professors Derrick Au and Hon Li for the opportunity to benefit from the discussions on that occasion. Johanna Seibt provided insightful feedback on the argument when it was presented at Aarhus University: I would like to thank Morten Dige and Mads Rosendahl Thomsen for the invitation to attend and present at the *Truly Human?* seminar. Nick Agar, Erik Malmqvist, and Catherine Mills were each kind enough to read a draft of the paper: I would also like to thank Chris Gyngell, Julian Savulescu, Rob Ranisch, and Inmaculada de Melo-Martin for correspondence while I was writing it. Mark Howard and Courtney Hempton assisted me with preparing the paper for publication.

References

Boorse, C. 1975. On the distinction between disease and illness. *Philosophy and Public Affairs* no. 5:49-68.

Boorse, C. 1977. Health as a theoretical concept. *Philosophy of Science* no. 44 (4):542-573.

Bostrom, N. 2003. Human genetic enhancements: a transhumanist perspective. *The Journal of Value Inquiry* no. 37 (4):493-506.

Buchanan, A. E. 2011. *Beyond humanity? The ethics of biomedical enhancement*. Oxford: Oxford University Press.

Callaway, E. 2014. 'Smart Genes' prove elusive. *Nature News*, September 8.

Card, D., A. Mas, E. Moretti, and E. Saez. 2012. Inequality at work: The effect of peer salaries on job satisfaction. *American Economic Review* no. 102 (6):2981-3003.

Chan, S., P. J. Donovan, T. Douglas, C. Gyngell, J. Harris, R. Lovell-Badge, D. J. Mathews, A. Regenberg, and O. B. o. t. H. Group. 2015. Genome editing technologies and human germline genetic modification: The Hinxton Group Consensus Statement. *The American Journal of Bioethics* no. 15 (12):42-47.

Church, G. M., and E. Regis. 2012. *Regenesis: How Synthetic Biology Will Reinvent Nature and Ourselves*. New York: Basic Books.

Cong, L., F. A. Ran, D. Cox, S. Lin, R. Barretto, N. Habib, P. D. Hsu, X. Wu, W. Jiang, L. Marraffini, and F. Zhang. 2013. Multiplex genome engineering using CRISPR/Cas systems. *Science*:1231143.

Daniels, N. 1985. *Just health care*. New York: Cambridge University Press.

de Araujo, M. 2017. Editing the Genome of Human Beings: CRISPR-Cas9 and the Ethics of Genetic Enhancement. *J Evol Technol* no. 27:24-42.

de Melo-Martín, I. 2016. *Rethinking Reprogenetics: Enhancing Ethical Analyses of Reprogenetic Technologies*. Oxford and New York: Oxford University Press.

Doudna, J. A., and S. H. Sternberg. 2017. *A crack in creation: Gene editing and the unthinkable power to control evolution*. Boston: Houghton Mifflin Harcourt.

Fletcher, J. F. 1974. *The rthics of genetic control: Ending reproductive roulette*. Garden City, NY: Anchor Press.

Garland-Thomson, R. 2019. Welcoming the unexpected. In *Human Flourishing in an Age of Gene Editing*, edited by Erik Parens and Josephine Johnston. Oxford: Oxford University Press.

Glover, J. 2006. *Choosing children: Genes, disability, and design*. Oxford: Oxford University Press.

Green, R. M. 2007. *Babies by design: the ethics of genetic choice*: Yale University Press New Haven, London.

Gyngell, C., and J. Savulescu. 2016. The Medical Case for Gene Editing. *Ethics in Biology, Engineering and Medicine: An International Journal* no. 6 (1-2):57-66.

Habermas, J. 2003. *The Future of Human Nature*. Cambridge, England: Polity Press.

Harris, J. 2007. *Enhancing evolution: The ethical case for making better people*. Princeton, NJ: Princeton University Press.

Harris, J. 2015. Germline manipulation and our future worlds. *The American Journal of Bioethics* no. 15 (12):30-34.

Hsu, P. D., E. S. Lander, and F. Zhang. 2014. Development and applications of CRISPR-Cas9 for genome engineering. *Cell* no. 157 (6):1262-1278.

Ishii, T. 2015. Germline genome-editing research and its socioethical implications. *Trends in Molecular Medicine* no. 21 (8):473-481.

Jinek, M., K. Chylinski, I. Fonfara, M. Hauer, J. A. Doudna, and E. Charpentier. 2012. A programmable dual-RNA–guided DNA endonuclease in adaptive bacterial immunity. *Science*:1225829.

Jonas, H. 1974. Biological engineering–a preview. In *Philosophical essays: from ancient creed to technological man*, edited by Hans Jonas. Englewood Cliffs, NJ: Prentice Hall.

Juengst, E., and D. Moseley. 2016. Human enhancement. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta.

Knoepfler, P. 2017. 4 key reasons Mitalipov paper doesn't herald safe CRISPR human genetic modification. In *The Niche: Knoepfler lab stem cell blog*.

Kolbert, E. 2018. The Psychology of Inequality. *The New Yorker*, January 15.

Kurzweil, R. 2005. *The singularity is near : when humans transcend biology*. New York, New York: Viking.

Lander, E. S. 2015. Brave new genome. *New England Journal of Medicine* no. 373 (1):5-8.

Lanphier, E., F. Urnov, S. E. Haecker, M. Werner, and J. Smolenski. 2015. Don't edit the human germ line. *Nature News* no. 519 (7544):410-411.

Lewis, C. S. 2015. *The abolition of man: Or, reflections on education with special Rrference to the teaching of english in the upper forms schools*. New Edition ed. Grand Rapids, MI: Zondervan.

Liang, P., Y. Xu, X. Zhang, C. Ding, R. Huang, Z. Zhang, J. Lv, X. Xie, Y. Chen, Y. Li, and Y. Sun. 2015. CRISPR/Cas9-mediated gene editing in human tripronuclear zygotes. *Protein & Cell* no. 6 (5):363-372.

Lin, L. F., and J. A. Kulik. 2002. Social comparison and women's body satisfaction. *Basic and Applied Social Psychology* no. 24 (2):115-123.

Ma, H., N. Marti-Gutierrez, S.-W. Park, J. Wu, Y. Lee, K. Suzuki, A. Koski, D. Ji, T. Hayama, R. Ahmed, H. Darby, C. Van Dyken, Y. Li, E. Kang, A.-R. Park, D. Kim, S.-T. Kim, J. Gong, Y. Gu, X. Xu, D. Battaglia, S. A. Krieg, D. M. Lee, D. H. Wu, D. P. Wolf, S. B. Heitner, J. C. I. Belmonte, P. Amato, J.-S. Kim, S. Kaul, and S. Mitalipov. 2017. Correction of a pathogenic gene mutation in human embryos. *Nature* no. 548 (7668):413-419.

Mali, P., L. Yang, K. M. Esvelt, J. Aach, M. Guell, J. E. DiCarlo, J. E. Norville, and G. M. Church. 2013. RNA-guided human genome engineering via Cas9. *Science* no. 339 (6121):823-826.

Malmqvist, E. 2007. Analysing our qualms about "designing" future persons: Autonomy, freedom of choice, and interfering with nature. *Medicine, Health Care and Philosophy* no. 10 (4):407-416.

National Academies of Sciences, Engineering, and Medicine. 2017. *Human genome editing: Science, ethics, and governance*. Washington, DC: The National Academies Press.

Nuffield Council on Bioethics. 2016. Genome editing: an ethical review. London: Nuffield Council on Bioethics

Ormond, K. E., D. P. Mortlock, D. T. Scholes, Y. Bombard, L. C. Brody, W. A. Faucett, G. Nanibaa'A, L. Hercher, R. Isasi, A. Middleton, and K. Musunuru. 2017. Human germline genome editing. *The American Journal of Human Genetics* no. 101 (2):167-176.

Parens, E. 1998. Is better always good? The enhancement project. *Hastings Center Report* no. 28 (1): S1-S17.

Passarino, G., F. De Rango, and A. Montesanto. 2016. Human longevity: Genetics or Lifestyle? It takes two to tango. *Immunity & Ageing* no. 13 (1):12.

Pearsall, J. 2002. Concise Oxford English Dictionary (revised). Oxford: Oxford University Press.

Powell, R., and A. Buchanan. 2011. Breaking evolution's chains: the prospect of deliberate genetic modification in humans. *The Journal of Medicine and Philosophy* no. 36 (1):6-27.

Prusak, B. G. 2005. Rethinking "liberal eugenics": Reflections and questions on Habermas on bioethics. *Hastings Center Report* no. 35 (6):31-42. doi: doi:10.1353/hcr.2005.0113

Ramsey, P. 1970. *Fabricated man: the ethics of genetic control*. New Haven: Yale University Press.

Regalado, A. 2015. Engineering the perfect baby. *MIT Technology Review* no. 118 (3):26-33.

Resnik, D. B. 2000. The moral significance of the therapy-enhancement distinction in human genetics. *Cambridge Quarterly of Healthcare Ethics* no. 9 (3):365-377.

Sandel, M. J. 2007. *The case against perfection: Ethics in the age of genetic engineering*. Cambridge, Mass. and London: Harvard University Press.

Savulescu, J. 2006. Justice, fairness, and enhancement. *Annals of the New York Academy of Sciences* no. 1093:321-338. doi: doi: 10.1126/science.1127990.

Savulescu, J. 2016. Why we should fine-tune the DNA of future generations. *Cosmos* no. 70:38-45.

Savulescu, J., J. Pugh, T. Douglas, and C. Gyngell. 2015. The moral imperative to continue gene editing research on human embryos. *Protein & cell* no. 6 (7):476-479.

Scheiber, N. 2014. The brutal ageism of tech: Years of experience, plenty of talent, completely obsolete. *The New Republic*, http://www.newrepublic.com/article/117088/silicons-valleys-brutal-ageism.

Scott, D. A., and F. Zhang. 2017. Implications of human genetic variation in CRISPR-based therapeutic genome editing. *Nature medicine* no. 23 (9):1095-1101.

Silver, L. M. 1999. *Remaking Eden: cloning, genetic engineering and the future of humankind?* London: Phoenix.

Sparrow, R. 2010a. Better than men? Sex and the therapy/enhancement distinction. *Kennedy Institute of Ethics Journal* no. 20 (2):115-144.

Sparrow, R. 2010b. Should human beings have sex? Sexual dimorphism and human enhancement. *The American Journal of Bioethics* no. 10 (7):3-12. doi: doi: 10.1080/15265161.2010.489409.

Sparrow, R. 2011a. Liberalism and eugenics. *Australasian Journal of Philosophy* no. 89 (3):499-517.

Sparrow, R. 2011b. A not-so-new eugenics: Harris and Savulescu on human enhancement. *Hastings Center Report* no. 41 (1):32-42.

Sparrow, R. 2012. A Child's Right to a Decent Future? Regulating Human Genetic Enhancement in Multicultural Societies. *Asian Bioethics Review* no. 4 (4):355-373.

Sparrow, R. 2015a. Enhancement and obsolescence: Avoiding an "Enhanced Rat Race". *Kennedy Institute of Ethics Journal* no. 25 (3):231-260.

Sparrow, R. 2015b. Genetically engineering humans: A step too far? *The Pharmaceutical Journal* 295 (7881).

Stock, G. 2003. *Redesigning humans: Choosing our children's genes*. London: Profile Books.

Swain, J., and S. French. 2000. Towards an affirmation model of disability. *Disability & Society* no. 15 (4):569-582.

Veit, W. 2018. Procreative beneficence and genetic enhancement. *Kriterion - Journal of Philosophy* no. 32 (1):75-92.

Wolbring, G. 2010. Obsolescence and Body Technologies. *Dilemata* no. 2 (4):67-83.