Human Engineering and Climate Change

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Abstract

Anthropogenic climate change is arguably one of the biggest problems that confront us today. There is ample evidence that climate change is likely to affect adversely many aspects of life for all people around the world, and that existing solutions such as geoengineering might be too risky and ordinary behavioural and market solutions might not be sufficient to mitigate climate change. In this paper, we consider a new kind of solution to climate change, what we call *human engineering*, which involves biomedical modifications of humans so that they can mitigate and/or adapt to climate change. We argue that human engineering is potentially less risky than geoengineering and that it could help behavioural and market solutions succeed in mitigating climate change. We also consider some possible ethical concerns regarding human engineering such as its safety, the implications of human engineering for our children and for the society, and we argue that these concerns can be addressed. Our upshot is that human engineering deserves further consideration in the debate about climate change.

Human Engineering and Climate Change

I. Introduction

Anthropogenic climate change, or climate change for short, is arguably one of the biggest problems that confront us today. There is wide agreement that climate change will affect the lives of all people around the world in areas such as food production, access to water, health, and the environment. Indeed, it has been estimated that millions could suffer hunger, water shortages, diseases, and costal flooding as a result of global warming (IPCC 2007; Stern 2007).

The risks of the worst impacts of climate change can be lowered if greenhouse gas levels in the atmosphere can be reduced and stabilised. To cut greenhouse gas emissions, various solutions have been proffered, ranging from low-tech, ordinary *behavioural solutions* such as encouraging people to drive less and recycle more; to *market solutions* such as carbon taxation, emissions trading, and other ways of incentivising industries to adopt cleaner power, heat, and transport technologies; to *geoengineering*, i.e., large-scale manipulations of the environment including reforestation, using space-based mirrors to alter planetary albedo, and fertilizing the ocean with iron to enhance carbon sinks (Keith 2000).

There is lively debate in the relevant literature about these different kinds of solutions. Each kind has its merits and demerits (Ekins and Barker 2001; Keith 2000; Kollmuss and Agyeman 2002). For example, an advantage of behavioural solutions is that they are ones that most of us could easily physically perform. Their disadvantages include the fact that many people lack the motivation to alter their behaviour in the required ways, and the fact that even if widely adopted, behavioural changes alone may

not be enough to reduce greenhouse gas emissions sufficiently to mitigate climate change. An advantage of market solutions is that they could reduce the conflict that currently exists for companies between making profit and minimising undesirable environmental impact. A disadvantage is that effective market solutions such as international emissions trading require workable international agreements, which has thus far seemed difficult to orchestrate. For instance, it has been argued that the Kyoto Protocol has produced no demonstrable reductions in emissions in the world (Prins and Rayner 2007). Moreover, it has been estimated that to restore our climate to a hospitable state requires us to cut our carbon emissions globally by at least 70 percent (Washington et al. 2009). Given the inelastic and rising demands for petrol and electricity, there are also issues about whether market solutions such as carbon taxation can by themselves be enough to deliver reductions of this magnitude. An advantage of geoengineering is that, in theory, its impact could be significant enough to mitigate climate change (The Royal Society 2009). Its disadvantages include the fact that, in many cases, we lack the necessary scientific knowledge to devise and implement geoengineering without significant risk to ourselves and to future generations. Some have therefore argued that no institution or nation-state has the right to attempt geoengineering (Jamieson 1996).

In this paper, we explore a new kind of solution to the problem of climate change. We call this kind of solution *human engineering*. It involves the biomedical modification of humans to make them better at mitigating climate change. We shall argue that human engineering potentially offers an effective means of tackling climate change, especially if implemented alongside the sorts of solution that we have already described.

To be clear, we shall not argue that human engineering ought to be adopted; such a claim would require far more exposition and argument than we have space for here. Our central aim here is to show that human engineering deserves consideration alongside other solutions in the debate about how to solve the problem of climate change. Also, as we envisage it, human engineering would be a *voluntary* activity – possibly supported by incentives such as tax breaks or sponsored health care – rather than a coerced, mandatory activity.

II. Human Engineering Solutions to Climate Change

To start, it will be helpful to have some possible examples of human engineering. Note that these examples are meant to be suggestive and we are not wedded to these particular examples. Although we think that these examples are not implausible, there may be better examples to illustrate our point that human engineering should be taken seriously. We invite readers to come up with such examples.

Pharmacological meat intolerance

A widely cited report by the United Nations Food and Agriculture Organization estimates that 18% of the world's greenhouse emissions (in CO_2 equivalents) come from livestock farming, a higher share than from transport (Steinfeld et al. 2006). More recently, it has been suggested livestock farming in fact accounts for at least 51% of the world's greenhouse emissions (Goodland and Anhang 2009). But even by the more conservative estimate, close to 9% of human CO_2 emissions are due to deforestation for expansion of

pastures, 65% of anthropogenic nitrous oxide is due to manure and 37% of anthropogenic methane comes directly or indirectly from livestock. Some experts estimate that each of the world's 1.5 billion cows alone emit 100-500 liters (about 26-132 gallons) of methane a day (Johnson and Johnson 1995). In addition there are sizeable negative impacts on water availability and biodiversity (Steinfeld et al. 2006). Finally, emissions from livestock is expected to increase very dramatically (Goodland and Anhang 2009).

Since a large proportion of these cows and other grazing animals are meant for consumption, reducing the consumption of these kinds of meat (for brevity, call them 'red meat') could have significant environmental benefits (Eshel and Martin 2006). Indeed, even a minor (21-24%) reduction of red meat consumption would achieve the same reduction in emissions as the total localization of food production, i.e., having zero 'food miles' (Weber and Matthews 2008).

While reducing the consumption of red meat can be achieved through social, cultural means, people often lack the motivation or willpower to give up eating red meat even if they wish they could. Human engineering could help here. Eating something that makes us feel nauseous can trigger long-lasting food aversion. While eating red meat with added emetic (a substance that induces vomiting) could be used as an aversion conditioning, anyone not strongly committed to giving up red meat is unlikely to be attracted to this option. A more realistic option might be to induce mild intolerance (akin, e.g., to milk intolerance) to these kinds of meat. While meat intolerance is normally uncommon (Aparicio et al. 2005), in principle, it could be induced by stimulating the immune system against common bovine proteins. The immune system would then become primed to react to such proteins, and henceforth eating 'eco-unfriendly' food

would induce unpleasant experiences. Even if the effects do not last a lifetime, the learning effect is likely to persist for a long time. A potentially safe and practical way of delivering such intolerance may be to produce 'meat' patches – akin to nicotine patches. We can produce patches for those animals that contribute the most to greenhouse gas emissions and encourage people to use such patches.

Making humans smaller

Another more striking example of human engineering is the possibility of making humans smaller. Human ecological footprints are partly correlated with our size. We need a certain amount of food and nutrients to maintain each kilogram of body mass. This means that, other things being equal, the larger one is, the more food and energy one requires. Indeed, basal metabolic rate (which determines the amount of energy needed per day) scales linearly with body mass and length (Mifflin et al. 1990)[1]. As well as needing to eat more, larger people also consume more energy in less obvious ways. For example, a car uses more fuel per mile to carry a heavier person than a lighter person; more fabric is needed to clothe larger than smaller people; heavier people wear out shoes, carpets, and furniture more quickly than lighter people, and so on.

A way to reduce ecological footprints, then, would be to reduce size. Since weight increases with the cube of length, even a small reduction in, e.g., height, might produce a significant effect in size, other things being equal (To reduce size, one could also try to reduce average weight or average weight and height, but to keep the discussion simple, we shall use just the example of height). Reducing the average US height by 15 cm

[1] Kleiber's law in biology states that metabolic rate scales as the $3/4^{th}$ power of mass of an animal. However, within the small size ranges we are discussing here the linear approximation should work.

would mean a mass reduction of 23% for men and 25% for women, with a corresponding reduction of metabolic rate (15%/18%), since less tissue means lower nutrients and energy needs.

How could such a reduction be achieved? Height is determined partly by genetic factors and partly through diet and stressors. While the genetic control is polygenetic, with many genes contributing a small amount to overall height, the growth process itself is largely controlled by the hormone somatotropin (human growth hormone). Given this, there are several ways by which we could reduce adult height in humans.

One way is through preimplantation genetic diagnosis (PGD). While genetic modifications to control height are likely to be quite complex and beyond our current capacities, it nevertheless seems possible now to use PGD to select shorter children. This would not involve intervening to change the genetic material of embryos, or employing any clinical methods not currently used. It would simply involve rethinking the criteria for selecting which embryos to implant.

Another method of affecting height is to use hormone treatment either to affect somatotropin levels or to trigger the closing of the epiphyseal plate earlier than normal (this sometimes occurs accidentally through vitamin A overdoses (Rothenberg et al. 2007)). Hormone treatments are used for growth reduction in excessively tall children (Bramswig et al. 1988; Grüters et al. 1989). Currently, somatostatin (an inhibitor of growth hormone) is being studied as a safer alternative (Hindmarsh et al. 1995).

Finally, a more speculative and controversial way of reducing adult height is to reduce birth weight. There is a correlation between birth weight and adult height (Sorensen et al. 1999), according to which birth weight at the lower edge of the normal

distribution tends to result in the adult's being ≈5 cm shorter. Birth height has an even stronger effect for adult height. If one is born at the lower edge of the normal distribution of height, this tends to produce ≈15 cm shorter adult height. Gene imprinting has been found to affect birth size, as a result of evolutionary competition between paternally and maternally imprinted genes (Burt and Trivers 2006). Drugs or nutrients that either reduce the expression of paternally imprinted genes, or increase the expression of maternally imprinted genes, could potentially regulate birth size.

Lowering birth-rates through cognitive enhancement

In 2008, John Guillebaud, an emeritus professor of family planning and reproductive health at University College London, and Dr Pip Hayes, a general practitioner from Exeter, pointed out that 'each UK birth will be responsible for 160 times more greenhouse gas emissions … than a new birth in Ethiopia' ((Guillebaud and Hayes 2008): 576). As a way to mitigate climate change, they proposed that Britons should consider having no more than two children per family.

Guillebaud and Hayes did not say how lower birth-rates should be achieved beyond suggesting that people should have this information and that they should have access to contraceptives. There are of course many other available methods of curbing birth-rates. However, there is also strong evidence that birth-rates are negatively correlated with adequate access to education for women (United Nations 1995). While the primary reason for promoting education is to improve human rights and well-being, fertility reduction may be a positive side-effect from the point of view of tackling climate change.

In fact, there seems to be a link between cognition itself and lower birth-rates. At least in the US, women with low cognitive ability are more likely to have children before age 18 (Shearer et al. 2002). So, another possible human engineering solution is to use cognition enhancements to achieve lower birth rates. Like education, there are many other, more compelling reasons to improve cognition, but the fertility effect may be desirable as a means of tackling climate change. Even if the direct cognitive effect on fertility is minor, cognition enhancements may help increase the ability of people to educate themselves (Sandberg and Bostrom 2006), which would then affect fertility, and indirectly climate change. We shall shortly consider the effectiveness of such an indirect strategy for tackling climate change.

Pharmacological enhancement of altruism and empathy

Another indirect means of mitigating climate change is to enhance and improve our moral decisions by making us more altruistic and empathetic.

Many environmental problems are the result of collective action problems, according to which individuals do not cooperate for the common good. In a number of the cases, the impact of any particular individual's attempt to address a particular environmental problem has a negligible impact, but the impact of a large group of individuals working together can be huge. If people were generally more willing to act as a group, and could be confident that others would do the same, we may be able to enjoy the sort of benefits that arise only when large numbers of people act together. Increasing altruism and empathy may help increase the chances of this occurring (Dietz et al. 2003; Fehr et al. 2002; Gintis 2000).

Also, many environmental problems seem to be exacerbated by—or perhaps even result from—a lack of appreciation of the value of other life forms and nature itself (Kollmuss and Agyeman 2002). It seems plausible that, were people more aware of the suffering caused to certain groups of people and animals as a result of environmental problems, they would be more likely to want to help tackle these problems. The fact that many environmental charities campaign to raise awareness of such suffering as a way of increasing donations supports this assumption.

There is evidence that higher empathy levels correlate with stronger environmental behaviors and attitudes (Berenguer 2007). Increasing altruism and empathy could also help increase people's willingness to assist those who suffer from climate change. While altruism and empathy have large cultural components, there is evidence that they also have biological underpinnings. This suggests that modifying them by human engineering could be promising. Indeed, test subjects given the prosocial hormone oxytocin were more willing to share money with strangers (Paul J. Zak et al. 2007) and to behave in a more trustworthy way (P. J. Zak et al. 2005). Also, a noradrenaline reuptake inhibitor increased social engagement and cooperation with a reduction in self-focus during a mixed motive game (Tse and Bond 2002). Similar effects have been observed with SSRIs in humans and animal experiments (Knutson et al. 1998). Furthermore, oxytocin appears to improve the capacity to read other people's emotional state, which is a key capacity for empathy (Domes et al. 2007; Guastella et al. 2008). Conversely, testosterone appears to decrease aspects of empathy (Hermans et al. 2006) and in particular conscious recognition of facial threats (van Honk and Schutter 2007). Neuroimaging work has also revealed that one's willingness to comply with social norms

may be correlated with particular neural substrates (Spitzer et al. 2007). This raises the likelihood that interventions affecting the sensitivity in these neural systems could also increase the willingness to cooperate with social rules or goals.

These examples are intended to illustrate some possible human engineering solutions. Others like them might include increasing our resistance to heat and tropical diseases, and reducing our need for food and water.

III. Taking Human Engineering Seriously

Why should we take human engineering solutions seriously? To answer this question, it is useful first to make explicit an assumption that we are making, namely, ordinary behavioural solutions such as driving less and recycling more and market solutions such as taxation and emissions trading are *by themselves* inadequate to mitigate climate change. We assume this in part because there is ample evidence that this may be the case (Rahmstorf et al. 2007; U.N. Environment Programme 2008) and because a number of experts on climate change seem to take far riskier solutions such as geoengineering seriously (House of Commons Science and Technology Committee 2010). If behavioural and market solutions were by themselves sufficient to mitigate climate change, it would not be necessary to take geoengineering seriously. Suppose that we should take geoengineering seriously and that behaviour and market solutions are by themselves inadequate to mitigate climate change. There are at least two reasons to take human engineering seriously. First, human engineering is potentially less risky than geoengineering. Second, human engineering could make behaviour and market solutions more likely to succeed. We shall explain each point in turn.

A common objection to certain existing or proposed geoengineering solutions is that they are too risky. Some geoengineering solutions, such as using space-mirrors to alter planetary albedo, pose risks to the planet and to future generations – risks that are compounded by the fact that these solutions often involve novel technology whose effects are little known. In contrast, at least the human engineering solutions we have described rely on tried-and-tested technology, whose risks, at least at the individual level, are comparatively low and well known. For example, PGD – the process that would enable us to select smaller children – is an accepted practice in many fertility clinics.[2] Or, oxytocin, which could be used to increase empathy, is already used as a prescription drug. Furthermore, given that human engineering applies at the level of individual humans, it seems that we can better manage such risks than the risks imposed by something like geoengineering which takes place on a much larger, global, scale. If one should take geoengineering seriously, and if human engineering has the potential to mitigate climate change while be less risky than geoengineering, this seems to be a good reason to take human engineering seriously.

Human engineering could make behavioural and market solutions more likely to succeed in the following ways. For one thing, pharmacologically induced altruism and empathy could increase the likelihood that we adopt the necessary behavioural and market solutions for curbing climate change. Or, pharmacological meat intolerance could make the behavioural solution of giving up red meat much easier for those who want to do so but who find it too difficult.

[2] For a discussion of the ethics of using PGD for non-medical uses, see, e.g., S. Matthew Liao, 'The Ethics of Using Genetic Engineering for Sex Selection', *Journal of Medical Ethics,* 31 (2005), 116-18, John Robertson, 'Pgd: New Ethical Challenges', *Nat Rev Genet,* 4/1 (2003), 6-6.

Moreover, human engineering could be liberty-enhancing when used alongside behavioural and market solutions. For example, given a certain fixed allocation per family of greenhouse gas emissions, each family may only be permitted to have two children, as Guillebaud and Hayes have proposed. However, if we were able to scale the size of human beings, then given the same fixed allocation of greenhouse gas emissions, some families may be able to have more than two children. Human engineering could therefore give people the choice between having a greater number of smaller children or a smaller number of larger children.

Furthermore, some human engineering solutions could be 'win-win' solutions in the sense that desirable effects are very likely to result from implementing them regardless of their effectiveness at tackling climate change. Cognitive enhancement, if effective at reducing birth rates, could enable China to limit or dispense with its controversial, coercive one-child policy. But even if the effect of cognitive enhancement on birth rates is disappointing, improved cognition is itself of great value. Or, consider pharmacological meat intolerance: if this method is effective at reducing greenhouse gases that result from the farming of certain kinds of animals for consumption, it could reduce the need to tax undesirable behaviour (such as consuming goods that are most damaging to the environment). But even if its effect on greenhouse gases is disappointing, the health benefits of eating less red meat and the reduction in suffering of animals farmed for consumption are themselves positive goods. In general, as well as helping to mitigate climate change, human engineering could also help solve some other serious problems of the modern world: smaller people, more considerate people, and

lower meat consumption, could, for example, help address the problems associated with unsustainable energy demands and water shortage.

IV. Potential Concerns Regarding Human Engineering

While there are positive reasons to pursue human engineering, there are also reasons to be concerned with human engineering. To defend the prospect of human engineering further, we consider some of these concerns in this section.

Safety

We have suggested that human engineering is potentially less risky than geoengineering. However, as with all biomedical treatments—including those routinely prescribed by medical professionals—human engineering still carries risks. The type and severity of risk will vary from procedure to procedure. There could, for example, be side-effects of making children smaller by giving them hormones. Indeed, the steroid treatments currently used to treat growth abnormalities may risk triggering an early onset of puberty or other hormonal imbalances. Also, somatostatin analogues may increase the risks of gallstones (Ahrendt et al. 1991). Or, increasing altruism and empathy using oxytocin might make a community more vulnerable to those who would take advantage of other people's trust and generosity. In fact, a study found that when informed about breaches of trust in their community, people are less likely to modify their trusting behavior if they have been given oxytocin (Baumgartner et al. 2008; Kosfeld et al. 2005). The possibility of these risks means that if people are to be persuaded to undergo human engineering, the risks associated with it must be minimized.

Our response is that acknowledge these risks exist, but also to point out that these risks should be balanced against the risks associated with taking inadequate action to combat climate change. If behavioural and market solutions alone are not sufficient to mitigate the effects of climate change, then even if human engineering were riskier than these other solutions, we might still need to consider it.

Also, it is important not to exaggerate the risks involved in human engineering. This is a very real possibility, since people are generally less tolerant of risks arising from novel, unfamiliar technologies than they are of risks arising from familiar sources (Slovic 1987; Starr 1969). To counter this effect, it is worth remembering that some of the technology involved in human engineering – such as PGD and oxytocin – is already safely available for other uses, and that in non-climate change contexts, our society has been willing to make biomedical interventions on a population-wide scale. For example, fluoride is deliberately added to water with the aim of fortifying us against tooth decay, even though doing so is not without risks. Similarly, people are routinely vaccinated to prevent themselves and those around them from acquiring infectious diseases, even though vaccinations can sometimes even lead to death. Given that biomedical modifications are accepted in these other contexts, and given that climate change is at least as serious as these other problems, again it seems that we should consider human engineering.

Furthermore, as we have mentioned earlier, a number of the human engineering solutions could be beneficial in other ways. Hence, while human engineering involves risks, it can also carry benefits over and above the contribution it makes to tackling

climate change. This makes it more likely to be voluntarily adopted than solutions that entail more costs than benefits to the individual.

On the whole then, with respect to safety, it seems that we should judge human engineering solutions on a case by case basis, and not rule all of them out *tout court*.

Interfering with human nature

Even if it is safe, since human engineering belongs to the general cluster of biomedical technologies that seek to modify or enhance humans, human engineering will raise the similar sorts of ethical concerns that are raised by biomedical enhancements generally. Owing to space, we shall just mention one such concern here for illustrative purposes (Liao 2008). In particular, Michael Sandel has argued that a problem with human enhancement is that it represents 'a Promethean aspiration to remake nature, including human nature, to serve our purposes and satisfy our desires' (Sandel 2004). Given that human engineering is using biomedical means for the sake of climate change, some might worry that this problem would similarly be present in human engineering. Indeed, a number of environmentalists believe that it is precisely our interference with nature that has given rise to climate change. These environmentalists might therefore object to human engineering on the ground that it too is interfering with nature.

First, the following view is surely too strong:

> **The Interfering with Nature View:** It is morally impermissible to interfere with human nature, because this is interfering with nature, and it is morally impermissible to interfere with nature.

Among other things, this view – at least in its unqualified form – implies (implausibly) that providing vaccination, offering pain relief to women in labor, and so on, are impermissible, since these acts interfere with nature. Also, not every human engineering solution involves 'interfering' with human nature, if by 'interference' one means making modifications to human beings. The selection of a smaller child through PGD, for example, involves no more interference with nature than the standard IVF process, a process to which many people do not object.

In addition, whilst many human engineering solutions involve interference with human nature, they also – by mitigating climate change – reduce our interference with nature at large. Indeed, if they turn out to be truly successful, they would bring about a net reduction in human interference with nature. As such, even those who oppose interfering with nature should not rule out human engineering on the ground that it involves interfering with nature, and should even – in the interests of reducing the total extent of human interference with nature – seriously consider supporting it.

Finally, Sandel is objecting to human enhancement partly because many people want to use it 'to serve our purposes and satisfy our desires.' It is true that human engineering in some respects serves our own interests and our children's interests. But human engineering is also an ethical endeavor in that mitigating climate change can promote the well-being of many people and animals that are vulnerable to the effects of climate change, and, as mentioned before, it can play an important role in preserving nature at large. Given this, it seems that even those who share Sandel's disapproval of the 'Promethean aspiration to remake nature, including human nature, to serve our

purposes and satisfy our desires' can consistently endorse consideration of human engineering.

Modifying our children

Whilst many human engineering solutions would involve individuals autonomously choosing to modify themselves, some would involve engineering children. Is it ethical for parents to make choices that may irreversibly affect their children's lives? This is an important issue, but it is worth remembering that not all human engineering solutions that would involve children are necessarily controversial. For instance, would we as parents really object to using cognitive enhancement on our children as a means of lowering birth rates? There is evidence that many parents are indeed happy to give their children cognitive enhancements. For example, a great many parents – perhaps even too many[3] – are willing to give Ritalin to their healthy children so that they can concentrate and perform better at school, even though Ritalin is intended for children with ADHD and certainly has side effects.[4]

With regard to those human engineering solutions that would involve children and that may be controversial – such as making children smaller – issues about a child's present and future autonomy and the limits of parental authority would certainly arise (Liao 2005). The extent to which we are concerned by this issue will vary from case to case. As a general remark, it is worth reminding ourselves why more controversial kinds of human engineering would be contemplated. They might be contemplated because there is evidence that existing solutions for mitigating climate change are likely to fall short of

[3] http://www.apa.org/ppo/issues/padhdtest902.html, http://www.apa.org/ppo/issues/pconstest.html
[4] http://www.msnbc.msn.com/id/14590058/

their intended goals, and because millions could suffer hunger, water shortages, diseases, and costal flooding if climate change were not mitigated. In the biomedical enhancement literature, some people believe that, however controversial a technology may be, parents have the right socially and biologically to modify their children as long as doing so would on the whole promote their children's well-being, and as long as there exists no better means of achieving such an end (J. A. Robertson 1994). Similarly, given the seriousness of climate change, and given the possible lack of alternative solutions, we might conclude that if a particular human engineering solution would on the whole promote a child's well-being, then parents should also have a right to implement such a solution even if the solution is a controversial one. Not everybody would subscribe to this line of reasoning, and we do not have space here for a full treatment of it; however, it suggests that we have reason not to rule out even controversial human engineering solutions, but to weigh them against other options.

Human engineering and society

Human engineering may be fine for individuals, but may turn out to be bad for the society as a whole. To motivate the ensuing discussion, we shall use the example of making people smaller, as that is one example that is likely to raise this sort of concern. Some people might worry that using human engineering to make people smaller would entail that the most disadvantaged members of societies would bear the brunt of the effort (and the associated risks) of preserving the environment. For example, the most disadvantaged members of societies already tend to be smaller than non-disadvantaged members of societies (Jansen and HazebroekKampschreur 1997). If one were to use

financial incentives to encourage people to be smaller, the most disadvantaged members of societies might not have the option to refuse these incentives and might therefore disproportionately bear the burdens of alleviating climate change.

We do not have the space to address this issue in full here, but it seems that the most plausible accounts of distributive justice should able to address this issue from their internal theoretical resources. For example, suppose that one were a sufficientarian (Crisp 2003), and believed that there is a 'sufficiency' level of height below which it would be disabling for anyone to be. One might make sure that those who are expected to be below this level are not given the incentives to take advantage of such human engineering. This may then ensure that everyone has sufficient height.

Best use of resources

Assuming that we have limited resources – in terms of time, money, brain power, and so on – to devote to mitigating climate change, allocating resources to pursuing human engineering will result in our having fewer resources to devote to other types of solution. This in itself may be a reason not to pursue human engineering. This argument has been used against both climate adaptation and geoengineering. Some might also worry that, compared to other solutions, human engineering offers relatively few benefits for the costs involved. This worry applies especially to human engineering solutions such as lowering birth-rates through cognitive enhancement or increasing altruism and empathy through oxytocin, which are relatively indirect means of mitigating climate change, in that they must pass through many steps in the causal chain before they can have an effect

on the problem. As a result, it might be thought that using human engineering to tackle climate change is a poor use of resources.

It may turn out to be the case that human engineering is not the best way of tackling climate change, just as it may turn out that various other, more familiar, types of solution are not the best ones either. But to concede this point now would ignore the widely-recognised fact that climate change remains a serious problem today and we do not currently know which solutions will be the most effective. Discovering the extent to which human engineering – or any of the other solution currently being considered – is worth pursuing is largely an empirical challenge, and one that we are far more likely to meet in a timely manner if we maintain open minds about which solutions will be best.

Limited appeal

Finally and perhaps the most obvious objection to our suggestion that human engineering solutions should be considered is: it's a preposterous idea! In particular, who in their right mind would choose to make their children smaller? We are well aware that our proposal to encourage having smaller, but environmentally-friendlier human beings is *prima facie* outlandish, and we have made no attempt to avoid provoking this response. There is a good reason for this, namely, we wish to highlight that examining intuitively absurd or apparently drastic ideas can be an important learning experience, and that failing to do so could result in our missing out on opportunities to address important, often urgent, issues. History is replete with examples of issues or ideas which, whilst widely supported or even invaluable now, were ridiculed and dismissed when they were first proposed. In 1872, Pierre Pachet, a professor of physiology at Toulouse, dismissed

Pasteur's theory of germs as a 'ridiculous fiction'. An internal memo at Western Union in 1876 remarked that 'this "telephone" has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us'. Lord Kelvin, the president of the Royal Society, claimed in 1895 that 'heavier than air flying machines are impossible'.[5] In 1943, Thomas Watson, the chairman of IBM, doubted that the world could need any more than five computers. And only a few decades ago, those who worried about climate change – now widely recognised as one of the most pressing problems of our age – were frequently dismissed as 'tree-huggers'. The lesson here is that, whilst we may often be good at judging which ideas are unworthy of pursuing, we are nevertheless sometimes vulnerable to dismissing useful and valuable ideas.

The suggestion that we make our children smaller for the sake of the planet is the most controversial of the solutions described here. The reason that many people responded negatively to this idea seems not to be that they were doubtful of its effect on climate change if implemented, but that they doubt many people could be persuaded to implement it. There is something to this belief: in our society, being tall is viewed as being advantageous. Studies show that women find taller men more attractive than shorter men (Kurzban and Weeden 2005), and that taller people enjoy greater career success (Judge and Cable 2004). Given this, it seems plausible that people will not want to make themselves or their children shorter.

In response to this, we can note, first, that the fact that a particular human engineering solution may not appeal to some people is not a reason to avoid making such

[5] These examples were sourced from http://www.get-in.us/1/index.php/publisher/articleview/?SGLSESSID=f2959458ec598ccb7a2ae820d01830af&/1/frmArticleID/8/ on 10th November 2008.

a solution available. Many things that are freely available in society appeal to a limited few and are given a wide berth by everyone else. Consider, for example, tattoos, bungee jumping, and running marathons. In the case of particular human engineering solutions with limited appeal, all other things being equal, it seems that it is better that these solutions are available and used by only a few than that they are unavailable to all.

Second, what may be unappealing today may not be so tomorrow. This could be because people's attitudes about what is appealing can and do change, especially if there are ethical reasons for a particular type of intervention. For example, people's attitudes towards vegetarianism have changed as a result of vegetarianism's ethical status. People's attitudes towards currently unappealing human engineering solutions may undergo a similar change as awareness spreads about the effects that these solutions could have on the problem of climate change. Our attitudes about the extent to which certain qualities are appealing can also change with changes in the people around us. A recent study shows that those who care about their weight are more likely to allow themselves to grow fatter when surrounded by overweight people than they are when surrounded by slim people (Blanchflower, Oswald et al., 2008). This suggests that, even if a relatively small number of people made their children smaller, this might result in a reduction in the extent to which having a certain minimum height is valued by others. With the right incentives, such as tax breaks, those others might be willing to have smaller children of their own.

Third, we should be on our guard against status quo bias. Other things being equal, people are disposed to favour their current situation over a new one. In fact, we are even disposed to favour the current situation when other things are not equal, and often

prefer to maintain the status quo over a new situation that is measurably better (Bostrom and Ord). Making our children smaller may be unappealing, but so is the prospect of having our children grow up in a world blighted by the environmental consequences of their ancestors' choices and lifestyles. To attempt to circumvent our preference for the current status quo, imagine that our pre-industrial ancestors are given a choice between a) a world populated by nine billion people who have intervened in their own biology such that most of them are smaller than they would otherwise have been, and who as a result live in a sustainable world; b) a world populated by nine billion people who have not intervened to affect their own height and who as a result live in a non-sustainable world; and c) a world populated by six billion people who have not intervened to affect their own height and who live in a sustainable world. It is not obvious that, to our pre-industrial ancestors, a) would stand out as the least appealing option. In fact, it seems plausible that they might prefer a) to b) or c), given that a) allows more people to live in a sustainable world. In dismissing certain human engineering solutions as unappealing, then, we should ensure that we are not thereby implicitly endorsing a more familiar, but certainly no more appealing, set of circumstances.

Finally, we should note that whilst it is tempting to focus on the most provocative examples of human engineering solutions – which, in this case, also happen to be the least appealing – it is not the case that human engineering is synonymous with lack of appeal. As we mentioned earlier, one way to reduce size and therefore carbon footprints is to reduce height. But another way to reduce size is to reduce weight, which would presumably be less controversial. In general, there is no reason why it should not be possible to develop human engineering solutions that, as well as helping to fight climate

change, are also highly appealing to individuals. Indeed, cognitive enhancements and pharmacological means of resisting meat are likely to appeal to many people, since improved cognition and the health benefits of vegetarianism are goods in themselves.

V. Conclusion

In this paper, we hope to have given a flavour of what human engineering solutions to climate change might involve. We argued that human engineering is potentially less risky than geoengineering and that it could make behavioural and market solutions more likely to succeed. We also considered some possible concerns regarding human engineering, and we suggested some lines of response to these concerns. No doubt much more can be said for and against human engineering. In fact, our hope is that more will be said regarding it in the context of climate change. Given that climate change is likely to affect many aspects of life for all people around the world, and given that behavioural and market solutions might not be enough to mitigate climate change, we believe that human engineering deserves to be considered and explored further in this debate.[6]

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