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Review Article

Environmental Equity and Evolutionary Engineering: Our Ecological Footprints and our Ethical Footprints

Paul W Brandt Rauf*

School of Biomedical Engineering, Science and Health Systems, Distinguished University Professor and Dean, Drexel University, USA

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***Corresponding author:** Paul W Brandt Rauf, School of Biomedical Engineering, Science and Health Systems, Distinguished University Professor and Dean, Drexel University, 3120 Market Street, Bossone 718-A, Philadelphia, PA 19104, USA

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Abstract

Climate change is a global crisis but it needs to be considered within the larger context of the overall unequal distribution of ecological footprints around the world now and into the future that threatens the survival of current and future generations in a way that is clearly unethical. Averting this eco-genocide will require an eco-enlightenment possibly through enhanced eco-consciousness and moral evolution. Advances in neuroscience and neuroengineering offer the possibility of such augmented neuro-cognition and enhanced moral reasoning through chemical, mechanical and genetic manipulation of brain circuitry. Although extreme, this may be the last best hope to align our ecological footprints with our ethical footprints and avoid eco-catastrophe.

Keywords: Neuroengineering; Ecological footprints; Brain circuitry

Introduction

The World Leaders' Climate Summit on Earth Day 2021 and the Glasgow Climate Change Conference last fall have been touted as significant turning points in the world's approach to addressing this increasingly obvious and drastic situation. It is now apparent to most people that climate change is having serious negative impacts on eco-systems and human health and well-being as well as generating economic and political instability. It is also becoming appreciated that the serious negative impacts of climate change are being most immediately and significantly felt by those populations that have contributed the least to the problem and have the lowest capacity to deal with the consequences. The global atmospheric/oceanic/terrestrial sink for carbon dioxide emissions (the primary contributor to climate change) represents just one example of an eco-system service that is inequitably shared, so climate change is only one aspect of a more general problem of global environmental injustice, namely the inequitable distribution of all eco-system services. This inequitable distribution is the result ecological colonialism (eco-colonialism) from unfair trade in eco-system services of which vital resources are imported to the developed countries from the developing countries and unwanted wastes are exported from the developed to the developing countries. This not only exacerbates the poverty trap of developing countries precluding hopes for their sustainable development but also represents a real threat to human health and life of current and future generations, in essence perpetrating global ecological genocide (eco-genocide). We should all feel an ethical obligation to prevent this eco-genocide, but in order to accomplish this our desired ethical footprint needs to be aligned with our ecological footprint [1].

The problem: Footprints, fairness and fatalities

The ecological footprint of any country, region, organization, population or individual is defined as the area of land and water ecosystems required to provide the resources that they

consume and to assimilate the wastes that they generate, wherever on the earth the necessary land and water are located. Critical corollaries of this definition are that an ecological footprint cannot be shared, i.e., it is an exclusive area that once used by one person or population cannot be used by another, and that the total available ecological footprint is finite, i.e., it is limited by the size of the earth [2]. Ecological footprints provide some quantitative measure for considering what a fair distribution of eco-system services might be, but as a finite and exclusive shared "good", ecological footprint analysis precludes certain options. For example, it is difficult to see how an unequal distribution of ecological footprints could be justified by a Rawlsian "difference principle" because making some better off than others cannot make the worse off better too, i.e., there can be no "trickle-down" effect [3]. As a starting point then, it would seem logical to assume that a fair distribution of eco-system services would approximate an equal distribution. If a person or population co-opts more than an equal share of available eco-system services (large footprint) then some other person or population will have a shrunken footprint and must get by with less.

Indeed, what we see happening is that developed nations use their economic and technologic capabilities to import eco-system services to support their over-sized footprints from developing nations leaving the latter with smaller available footprints (eco-colonialism). An equal distribution of the global ecological footprint would provide each person in the world about 1.8 ha. Developed countries average footprints of approximately 4-10 ha/capita while the least developed countries average footprints of approximately 0.33-1 ha/capita. Unfortunately, one of the worst countries from this perspective is the United States where the average ecological footprint is about five times the global average and up to 15 times that of the least developed nations [2,4]. This means that the United States must "import" approximately half of its biocapacity from the rest of the world to sustain its lifestyle forcing the least developed countries to have smaller footprints. This deficit cannot be made up by traditional approaches such as technical and financial aid from the developed to the less developed countries to help them achieve equivalent lifestyles because, as noted, the available global ecological footprint has a real physical limit, and, in addition, current global consumption and waste has already exceeded the earth's sustainable carrying capacity. It is estimated that we already use the equivalent of 1.6 planet earths to provide our resources and absorb our wastes in a way that would be sustainable [4]. If we were able to provide the entire world's population with an American life-style in a sustainable fashion it would take at least four more planet earths [4]. Thus, the present state of eco-colonialism has serious implications for both intra-generational and inter-generational environmental justice.

From the perspective of intra-generational environmental justice, current climate eco-colonialism by itself is not only contributing to poverty and stunted economic development in less developed countries (the so-called "social cost of carbon") but also to ill health and premature death in marginal populations world-wide (the so-called "mortality cost of carbon") [5]. For example, if we consider carbon footprints alone (which contribute to climate change but represent only a portion of our total ecological footprints), it is estimated that right now every year climate change cause $125 billion in economic losses and leaves over 300,000 people dead and 325 million seriously affected around the globe. By 2030, it is estimated that this annual toll will be 500,000 dead and 600 million seriously affected [6]. The 50 least developed countries contribute less than 1% to global carbon emissions, but 98% of those seriously affected by climate change live in these less developed countries [7]. Taking into consideration all inequitable ecological footprint analysis would make these numbers affected even higher. Death and devastation on this scale could certainly be considered equivalent to genocide (eco-genocide).

Responsibility for this morbidity and mortality clearly does not rest with the populations who are suffering the effects. Considering climate change alone, at least 15% of greenhouse gas emissions are attributable to the US population (approximately 4% of the global population) [8]. With a rough estimate of the US population of 330 million, for climate change effects we can attribute 1 seriously affected individual annually to the combined carbon footprints of every 6 Americans and 1 fatality annually to the combined carbon footprints of every 6000 Americans; or, in other words, over the course of a lifetime (estimated at about 79 years) every American will adversely affect the health of approximately 13 individuals and every 75 Americans will cause the death of an individual somewhere in the world due to their contribution to greenhouse gas emissions and the resultant impact on climate change. And these may be conservative estimates because greenhouse emissions will not remain static but will continue to grow significantly even under the most conservative scenarios. For example, a recent study has suggested that the lifetime greenhouse emissions beyond current levels of a small handful of average Americans (i.e., 3.5) will result in one additional death in this century [9]. As noted, these numbers would be even worse if we accounted for the entire ecological footprint of the country.

If we accept this argument that we in the developed world are responsible for a significant burden of death and disability by our eco-colonialism, how can we ethically justify our lifestyle? If we personally knew the people that we were causing to sicken and die by our behavior, I would like to think that we would all be propelled to change to avoid this outcome. Thought experiments support this reasoning. A much-cited example is provided by the Australian philosopher Peter Singer in which he imagines a person dressed for an important interview walking by a pond in which a child is clearly drowning; jumping in to save the child will ruin the suit and result in the person being late for the interview [10]. Nevertheless, most people think it would be wrong not to save the child. The philosopher Peter Unger provides another example based on the trolley problem. A person has saved all his life to buy a valuable old car which he takes out for a drive but parks it on a railway siding to take a walk along the tracks. He sees a runaway train headed down the track toward a child who will be killed unless he acts. Fortunately, he is standing next to a switch which

can divert the train from the track to a siding thereby saving the child but destroying his vintage car [11]. Once again, most people would sacrifice the car to save the child's life. And we know from experience that this is how people behave. When children get stuck in a well, we generally mobilize significant resources to extricate them. When a child is drowning in the surf, people will put their own lives at risk and form a human chain to reach the child and pull it to safety. Is there any rational difference between these cases and how we should be willing to reduce our ecological footprints to save lives?

The choice: Eco-enlightenment vs eco-genocide

Over the course of human evolution our species has been characterized by both violence and altruism toward our fellow humans. This conflicted moral sensibility probably makes sense evolutionarily. Our Paleolithic ancestors wandering the African savannah upon meeting another unknown human would have had to make a quick decision about whether the person represented a potential ally or threat, the latter likely being the default assumption until proven otherwise, making it wise from an evolutionary perspective to kill first rather than risk being killed and being erased from the evolutionary gene pool. On the other hand, as inherently social animals, humans have clearly obtained an evolutionary advantage by cooperating with known fellow humans by which ensuring greater success in preserving their gene pool. However, for most of human history, the group of known humans who could be judged to be sufficiently trustworthy for cooperation rather than competition was severely circumscribed, limited to immediate family, kin or tribe members, the people they knew personally. Although some have offered hope that over the long view of human history we may actually be tending toward "the better angels of our nature" with decreasing violence and increasing empathy toward our fellow humans [12], there still remains considerable indifference toward the welfare of others that are distant, faceless and unknown compared to those identified or in our immediate circle. However, in our modern world we have evolved the considerable ability to inflict massive harm on distant populations through active violence (e.g., nuclear warfare) or passive violence (e.g., eco-genocide). It should also be noted that these forms of violence are linked; increasing ecological disasters could precipitate increasing warfare. Hence, our abilities to inflict harm have evolved much more rapidly than our genes, and we suffer the resultant dilemma of a mis-match between our Paleolithic genome with its concomitantly evolved, locally circumscribed moral consciousness now stranded in a global, post-modern technologic world. This raises the prospect that we may be the first species that causes its own extinction.

Peter Singer has noted that our survival as a species may require "expanding our circles of empathy" to include all member of our species, as well as member of other species [13]. From the ecological perspective, to avoid continuing eco-genocide and ultimate eco-catastrophe will require an eco-enlightenment which will be at least partially dependent on expanding our eco-consciousness. As the psychologist Joshua Greene has described the problem, we evolved moral intuitions that give us rapid but rigid answers, automatic "point-and-shoot" responses, that work reasonably well for proximate, known, immediate and common face-to-face situations but that fail for more distant, unknown, faceless and complex situations [14]. For the latter, we need to be able to switch from the "automatic" mode to a "manual" mode based on a higher form of moral reasoning to work out the correct answers from scratch to realize, for example, that there really is no significant moral difference between sacrificing your valuable car to save the child from a runaway trolley or sacrificing a portion of your ecological footprint due to your lifestyle to save children from dying of emergent infections or rising sea levels due to climate change in the developing world. This raises intriguing questions. Is it possible to help people to rely less on an automatic mode of moral intuition and more on a manual mode of moral reasoning, in essence to correct the mis-match between our evolved morality and our modern problems, to expand our eco-consciousness? If it is possible, should we do it? If it is possible, can we afford not to do it?

A potential solution: Enhanced moral evolution

Despite the extremely dark history of mis-guided eugenics, the concept of enhanced human evolution has seen a recent revival [15]. Indeed, as medical knowledge and ability advances there is a constant tension between what we can do and what we should do in improving health. If we define health as the WHO does, namely "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" [16], when exactly are we "complete"? Certainly, we believe if one is diseased or infirm we should intervene to cure if possible, and we increasingly believe that if one is at risk of becoming diseased or infirm we should intervene to remove or alleviate the risk factors responsible in order to prevent if possible. But what if we are "normal"? Is "normal" now acceptable as "normal" forever? As noted above, our current "normal" is constrained by a mis-match between our Paleolithic genome and our post-modern environment. This mis-match puts us at risk for many of the chronic diseases with which we are afflicted. For example, we evolved to deal with an environment of nutritional scarcity, and now we live in a high-calorie, high-fat, high-salt environment that predisposes to metabolic syndrome, obesity, diabetes, hypertension, and many other chronic illnesses. If we cannot or will not change the environment, should we try to change our physiologic nature to achieve a state of complete physical well-being? Similarly, if our evolved mental and moral reasoning state is incapable of dealing with the global eco-genocide and eco-catastrophe we are committing, should we try to enhance our neuro-cognition and related moral reasoning to achieve complete mental and social well-being that includes eco-enlightenment?

Discussion

With recent advances in neuroscience and neuroengineering, augmented neuro-cognition and enhanced moral reasoning are within the realm of possibility. Moral judgments can be altered through either chemical or mechanical manipulation of brain

circuitry. For example, using drugs that inhibit synaptic serotonin reuptake resulting in increased serotonin levels made people less likely to endorse harming one to save many others (i.e., more non-utilitarian in their moral judgments) [17]. Similarly, studies have demonstrated that non-invasive transcranial direct current stimulation of the left dorsolateral prefrontal cortex shifts preference of moral judgements to the non-utilitarian [18]. Transcranial direct brain stimulation can increase honesty and decrease bias in decision-making [19,20]. So, might it also be possible to "expand our circles of empathy" sufficiently to achieve eco-consciousness in the way we choose to lead our lives? One approach to this might be by appealing to and augmenting individuals' religious sentiments since, as has been previously noted, almost all world religions have a prominent eco-theological component that encompasses both a respect for the environment and a concern for the welfare of current and future generations [21]. So, it is interesting to note that in transcranial magnetic stimulation studies, individuals' implicit religiousness/spirituality increased after inhibiting activity of their inferior parietal cortex [22]. Furthermore, a review of recent studies demonstrated brain stimulation effects that would obviously have direct relevance to aligning our ethical footprints with our ecological footprints including increasing altruism, trust, cooperation, fairness, empathy and other prosocial behaviors such as an enhanced willingness to intervene to help others [23]. Of course, using current technology this would require voluntary participation and result in temporary effects. However, genetic engineering offers the prospect of effects that could be permanent and even heritable. For example, single genetic polymorphisms in the oxytocin receptor gene exist that favor non-utilitarian moral decision making [24]. CRISPR gene editing could introduce or remove such polymorphisms in brain cells or germ cells to achieve the desired moral judgments in existing or future populations. If this seems too farfetched, consider that researchers in China apparently already produced CRISPR-engineered babies with the good intention of preventing HIV infection [25].

Such evolutionary engineering could potentially allow us to escape the mismatch between our Paleolithic genome and our modern environment. Of course, what the desired moral judgments should be and who would decide remain critical issues yet to be debated. However, it has been argued that human enhancements should be considered a potential solution to climate change [26], that editing the genome deal with climate change may be ethically justifiable [27] and that we may be morally obligated to pursue moral enhancement in general perhaps to the point of moral perfection [28]. Furthermore, such human engineering could be potentially less risky than alternatives such as planetary geoengineering [29].

Conclusion

We are not ready or able yet to become the species Homo deus [30], but to achieve environmental equity would/should we be willing to allow evolutionary engineering to become Homo sapiens 2.0 to avoid eco-catastrophe that would decide the fate of the species for us. As a prominent neuroscientist has recently argued: "I don't see why the path of unguided evolution is preferable over a path of our own choosing….If gene editing keeps our entire species from going extinct then it becomes an imperative" [31]. This is clearly an extreme option, but one way or another, it does seem imperative that we find a way to make our ecological footprints and our ethical footprints align; otherwise, we may not be a species worth saving after all.

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