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REPLY

# Reply to Comment on 'The climate mitigation gap: education and government recommendations miss the most effective individual actions'

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## Abstract

In their comment piece, van Basshuysen and Brandstedt raise three main issues: first, whether population at the global scale, or individual family planning decisions, are relevant for climate change mitigation; second, they offer useful critiques of the methodologies to attribute greenhouse gas emissions for the choice to have a child; and third, they question the appropriate ethical responsibility for emissions resulting from personal choices. Here we reply that first, we consider choices regarding family size to meet the authors' criteria for actions 'under the control of the individual agent and which, with a significant probability, contribute to' (increased greenhouse gas emissions), and therefore are relevant to consider for climate mitigation. Second, we acknowledge both methodological issues inherent in allocating responsibility for emissions, and encourage more research on this topic especially for the climate impact of reproductive choices. Third, we address ethical questions about responsibility for emissions, and conclude that while such discussions are important, and individual choices are only one part of necessary emissions reductions, people alive today are the last to have a chance at remaining within the carbon budget to meet international climate targets, and therefore do have a special responsibility to reduce emissions.

## 1. Does population matter for climate change?

At the global scale, van Basshuysen and Brandstedt question the importance of the number of people on earth for climate change, stating 'If the world succeeds in transitioning to a net-zero carbon economy in due time, the population variable will become less relevant.' They are correct that each of the four terms in the familiar Kaya equation comprising total emissions (population, GDP per capita, energy intensity, and carbon intensity) are mathematically equivalent, since they are multiplied together, so a decrease in any one term will decrease overall emissions. Of course, beyond this scientific fact, political, economic, and ethical preferences may be very different for which term(s) to address and how best to do so, and are important social debates.

However, historical data show that the two major drivers in the increase in global emissions from 1970–2010 were population and GDP; improvements in energy intensity have nearly offset the increased emissions from population since 1990, but changes in carbon intensity (due to energy source) have played a very minor role historically, and switched from a net sink to a net source of emissions during 2000–2010 (Victor *et al* 2014). Thus, it is not only the energy systems and the consumption patterns that are pursued, but also the number of people pursuing them that matters for climate change. Further, even in a fully decarbonized society where carbon intensity and therefore total greenhouse gas emissions drop to zero, additional people on the planet will entail material and ethical trade-offs for critical issues such as land use, food production, biodiversity loss, resource use, and equity (a problem that van Basshuysen and Barnstedt acknowledge).

At the individual level, van Basshuysen and Brandstedt state it is not clear that the decision to have a child falls under the category of actions that should

be in focus for climate mitigation, which they argue are those 'under the control of the individual agent and which, with a significant probability, contribute to the undesired outcome' (of increased greenhouse gas emissions). We agree these are reasonable criteria, and we believe the decision whether to have a child meets both of them. First, while the 'universal access to sexual and reproductive health and reproductive rights' set out in Sustainable Development Goal Target 5.6 (United Nations 2015) is far from met today, these preconditions for family planning are most widely achieved in the developed countries where we focused our study. An individual planning the size of their family has control over the magnitude of potential emissions of their descendants in two ways: first, in completely preventing these emissions from occurring, if they choose to not create those descendants in the first place, and second, as the authors point out, in that their consumption choices (based on where and how they live) are likely to determine the emissions of their descendants. Therefore, we believe the decision to have a child is highly relevant to consider as a potential high-impact climate choice for an individual living in a developed country today.

## 2. Methodological accounting for greenhouse gas emissions from reproductive choices

The comment authors raise important methodological critiques of carbon accounting in general, and for reproductive choices in particular, especially regarding the multiple generations involved. In general, the issue of double counting is a prevalent methodological issue in carbon accounting, and avoiding it is a major concern for parties to the Paris Agreement, where key strategies have been identified to do so (Schneider *et al* 2015). For any individual choice, not just having children, one could envision double counting issues being created by including more individuals in the analysis. To take the flying example that the authors raise: how should emissions of an individual on a transatlantic flight be allocated? Do they belong to the airplane manufacturers, the airlines, the government, or air travelers themselves? Many individuals in that sequence can choose to reduce emissions without leaving the decision up to the passenger.

Another potential issue with double-counting that van Basshuysen and Barndstedt raise involves the case of compensation for victims of climate change. Certainly, if compensation for climate change victims were desired, additional research would need to be undertaken to support a well-designed mechanism to do so without double-counting. While there are methods to trace greenhouse gases from producers to specific impacts, this was not the intent of our analysis, and we do not envision that our analysis would be appropriate to inform such a mechanism.

As the authors point out, accounting for an individual's carbon legacy via reproductive choices necessarily entails an important series of assumptions, which they examine and provide suggestions for potentially improving. This includes assigning a child's emissions to the parents only up until the legal voting age, at which point the child would assume emissions responsibility. We believe that such approaches, and their methodological and ethical implications, deserve consideration.

Further analysis is especially important given the very long timeframe of ongoing emissions resulting from creating new people who will likely go on to have descendants. While van Basshuysen and Barndstedt rightly point out that future greenhouse gas emissions depend on trajectories involving interactions of population, consumption, and technologies that are subject to uncertainties, our analysis explicitly focused on 'scenarios most representative of current conditions (without additional policies)' (table S4, Wynes and Nicholas 2017). We did so in order to provide the most relevant information for individuals currently considering which of their choices have the highest climate impact. A separate analysis that explicitly aimed to model the impact of actions under different future scenarios would be required to evaluate the impact of various choices under net-zero or negative emissions scenarios. (However, recent analyses show that negative emissions scenarios imply substantial tradeoffs for water and land use, biodiversity, and biogeochemical flows (Heck *et al* 2018), so we cannot assume that negative emissions scenarios would mean that additional people have no material impacts overall.)

Our study of studies relied on the published literature. We were able to make use of nine different studies to examine the impact of owning a hybrid car (column 4, table S4, Wynes and Nicholas 2017), but we only identified one study quantifying the climate impact of having children (Murtaugh and Schlax 2009). More estimates using different approaches would provide a better understanding of how assumptions and techniques affect the estimate of the carbon legacy of having a child. However, regardless of methodology used, we are convinced (as the comment authors may also be, given that they 'do not dispute the potentially high impact on GHG emissions of a decision to have a child') that having one fewer child is the most substantial action that most individuals can take to make a quantifiable reduction in personal carbon emissions.

## 3. Ethical responsibility for emissions

Turning to the broader question of who bears responsibility for climate change and its mitigation, science may have methods to help account for sources of emissions, but ultimately this is an ethical question. It is

particularly difficult with climate change due to the long lifetime of greenhouse gases in the atmosphere, such that the impacts we are feeling today are caused by all preceding generations' choices as well as our own, and the choices we make today will affect people born long after we are dead. Different approaches to allocate responsibility (summarized in Victor *et al* (2014)) consider total emissions, historical responsibility, international trade, per-capita emissions, carbon efficiency, or the baseline year chosen. As the authors point out, nearly all actions in current fossil fuel societies are involved in causing greenhouse gas emissions. They question how the relative importance of these actions should be determined. Doing so was precisely our aim, in aggregating the best available data for lifecycle emissions from individual choices under current conditions to quantify their climate impact, in order to inform individuals which of their choices in fact make the biggest climate impact and are therefore worthy of the most thoughtful consideration. In particular, we focused our analysis on options for high-emitting individuals to reduce their emissions, since as we pointed out, such individuals produce nearly 50% of emissions today and will need to undertake steeper reductions to meet the low per-capita emissions necessary to meet international climate targets.

Of course, climate change is not only an individual issue. We share the fundamental ethical conclusion reached in the Paris Agreement that climate change is a problem for everyone on Earth, and everyone bears some responsibility for solving it. In pondering intergenerational responsibility, van Basshuysen and Brandstedt question 'why it is that the current generation is the special one that shoulders the main share of responsibility.' We can equally ask why previous generations did not take responsibility for reducing emissions sooner, leaving those of us alive today and future generations with a bigger challenge. These philosophical questions are worthwhile, but meanwhile the remaining carbon budget to stay below 2 °C can be interpreted as two decades at most at current emissions rates (Global Carbon Budget 2016), meaning it is the actions of those of us alive today that will determine whether we stay within this budget or not. At this point, efforts to eliminate greenhouse gas emissions fast enough to avoid dangerous climate change will benefit both from individuals choosing lower-carbon lifestyles, and from individuals acting in many ways beyond their household and family planning choices, including as community members, leaders in government, civil society, or business, and through collective action, all of which can contribute to meaningful climate mitigation.

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