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REVIEW

Navigating cognition biases in the search of sustainability

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Abstract We provide a conceptual review of the available knowledge on the role of human cognition biases for sustainability and sustainable behavior. Human cognition biases are defined as any deviation in decision making from the standard framework of rational choice. We distinguish between biases in individual decision making and biases in group decision making, and highlight the relevance of each for sustainable behavior. We find that while both categories may contribute to unsustainable behavior, human cognition biases in group settings might be central to understanding many of the current sustainability issues. Moreover, we argue that the effects of group-related biases may outweigh those on the individual level in driving unsustainable behavior, and that biases that have been discussed under various labels in the literature can be interpreted as manifestations of human cognition biases in group settings.

Keywords Environmental decision making · Human cognition biases · Rational choice · Sustainable behavior

INTRODUCTION

Sustainability challenges such as land-system change, pollution, excessive manipulation of biogeochemical cycles, and climate change have been on political agendas for decades. These pressing sustainability issues have been clearly delineated, and extensively studied, by the Club of Rome in the 1970s (Meadows et al. 1972), the Brundtland commission in 1987 (World Commission on Environment and Development 1987), the Millennium Ecosystem Assessment in 2005 (Millennium Ecosystem Assessment 2005), and others (e.g., Kates and Parris 2003; Biermann et al. 2012; Steffen et al. 2015). Yet, despite considerable awareness of the problems humanity faces, implementable solutions remain thin on the ground and there is much room for improvement for the solutions that have been implemented to date (Meadows 1997; Fischer et al. 2007; Ekins 2011). Fossil fuels are consumed quicker than ever, leading to a decreasing chance of keeping global warming within 2° of pre-industrial levels (McGlade and Elkins 2015). Agricultural land is lost due to degradation or conversion at an unprecedented rate (UNEP 2014), and one has to go 250 million years back in Earth's history to the so-called Great Permian Extinction to find a match to the current rate of loss of biodiversity (WWF 2016). Many different root causes of unsustainability have been suggested, ranging from humanities disconnection from nature (e.g., Pyle 1993), through our choice of economic system (e.g., Daly 1977) and technological change (Ehrenfeld 2013). In addition to such causes, human behavior and decision making, which is reflected in public policies, private consumption and business management plays a substantial role in shaping and perpetuating the sustainability challenges of our time (Antal and Hukkinen 2010; Kaaronen 2017). Indeed, issues of irrational behavior and decision making are likely to exacerbate or reinforce other underpinning drivers of unsustainability, such as technological change, or unsustainable economic structures. Thus, the question arises, if we know for certain that we cannot continue living like we currently do, are there facets of human behavior and decision making that are limiting the shift to more sustainable trajectories?

Many approaches to both explain and tackle unsustainability are built upon theories that involve some notion of human 'rationality' or 'rational choice.' For example, the excessive use of fossil fuels well beyond what would be considered reasonable can be explained within the framework of rational choice from economics: the use of fossil

fuels incurs costs due to pollution which are however not reflected by the market price, i.e., there is a market failure leading to a market price of fossil fuels that does not reflect its true societal cost (e.g., Hanley et al. 2013). The rational response to such a market failure is a tax on the good that reflects its true societal costs (Pigou 1920). Even though some countries have implemented such a tax on carbon, the majority still have not, including the world's single largest CO2 emitter, the United States (World Bank 2016). So, to render our question more precisely, if we know what is wrong and how to potentially address it, why does it take so long to bring about actual change? Is it just the fact that systems as large, interconnected, and complex as humanity on Earth are very slow to react by nature, or is it worthwhile to consider systematic deviations from rationality as a possible explanation to unsustainable decision making and behavior?

The present paper explores these questions from the viewpoint of social, behavioral, and environmental psychology. We argue that the concept of human cognition biases can be used as a substantive factor in explaining many cases of unsustainable decision making and behavioral practices. In addition, we ponder how our understanding and knowledge of human cognition biases might be used to work towards solutions to one of the 'grand challenges in environmental psychology' that is the promotion of sustainable behavior (Sörqvist 2016). We understand the term "human cognition bias" as all systematic deviations from the standard of rationality, and adopt Gilboa's and Schmeidler's widely accepted definition of rationality where a decision is rational (i.e., unbiased), if "when the decision maker is confronted with an analysis of the decisions involved, but with no other additional information, he/she does not regret her choices" (Gilboa and Schmeidler 2001, pp. 17–18).[1] There is a strong link between human cognition biases and the normative goal of sustainability. Definitions of the concept of sustainability typically rely on the notion of justice as a key concept (World Commission on Environment and Development 1987). Justice may be a goal with respect to individual members of or groups within a society that live at the same period of time (intra-generational justice), or it may be strived for with respect to members of or groups within different generations (intergenerational justice). Any attempt to attain a more just state of things involves making decisions, and almost all decision problems involve some uncertainty—usually referred to as risk—regarding possible future states of the world. Some human cognition biases are directly related to decision making under risk, and have thus a direct impact on the justice dimensions of sustainability. What is more, political decisions are mostly taken by groups rather than individuals. Yet, group decision settings give rise to a set of human cognition biases that may play a key role in hampering the decision quality regarding intra- as well as intergenerational justice. With this relationship of human cognition biases and sustainability in mind, we distinguish between biases in group settings and biases on the individual level, explain how these may play into promoting unsustainable behavior, and synthesize some take-home messages towards more sustainable decision making and behavior.

The major contribution of our paper is thus an analysis of the role of human cognition biases in individual and group decision making in the general context of sustainability. Existing contributions either focus on mainly one specific bias and discuss how policy making could be improved with regard to that bias (e.g., Thaler and Sunstein 2009; Arbuthnott and Dolter 2013), or they discuss a selection of human cognition biases on the *individual* level in relation to one single sustainability-related aspect, e.g., climate change (Bazerman 2006; Hoffman and Bazerman 2007; Shu and Bazerman 2010; Gifford 2011; Stoknes 2015) or conservation (Clayton et al. 2013) without particular discussion of the role of *group* settings. It has been pointed out recently that biases in sustainability-related group decision making are under-researched (Attari et al. 2014). Here, based on our synthesis, we argue that, in conjunction with biases on the individual level, which are obviously still present in each constituting member of a group, it is largely the biases on the group level that perpetuate unsustainable decisions and behavior.

METHODS

No complete and universally accepted list or repository of all scientifically well-established cognitive biases known currently exists to the best of our knowledge. Tversky and Kahneman (1974) identified three broad heuristics each of which contains multiple possible cognition biases, while in a review of the literature, Hogarth (1980) identified 29 distinct cognition biases and Bazerman (2008) identified broad 13 types of biases. No such list claims to be complete; each tends to be based on a specific context (e.g., uncertainty, management, information processing) and each provides different ways of organizing and categorizing cognition biases (see Das and Teng 1999 for a more detailed discussion of the proliferation of cognition biases).

[1] Another, more detailed definition of rationality has been promoted in Milkman et al. (2009), who define a rational decision as one where preferences are transitive and insensitive to minor changes of context, stated and revealed preferences coincide, and lastly as one in which "upon careful and cool reflection, a decision maker should remain satisfied after making a choice that the decision made was the right one" (ibid, p. 380). Similar definitions apply to group rationality (e.g., Baillon et al. 2016).

At the time of writing, the most encompassing list seems to be Wikipedia's (https://en.wikipedia.org/wiki/List_of_cognitive_biases), which currently lists just over 200 different cognitive biases. Because human cognition is a very active field of research, the list can be expected to grow. We thus recognize that this is not a stable list, but maintain that it is the best access point available to the wide array of human cognition biases. With these preliminary considerations in mind, to assess the current literature on cognition biases and their relevance for sustainability, we decided to focus on those biases that are relevant to decision making under risk/uncertainty or inter-group settings as these are pivotal aspects of most, if not all, sustainability challenges (Dovers and Handmer 1992). Altogether, our selection of biases to be included and discussed here was therefore based on three pillars: (1) pre-selection according to theme or situation of bias occurrence based on the above list, (2) screening of books (Taleb 2001, 2007; Kahneman 2011; Dobelli 2013) as well as (3) the authors' own research experience and practice in the field of decision theory, with particular focus on decision making under risk and uncertainty (Abson and Termansen 2011; Baumgärtner and Engler 2015; Engler 2015). The result of this literature screening process was a refined list of biases grouped according to the themes 'individual/risk-related' and 'group settings.' In the next step, we discussed and decided which of the biases on our refined list were relevant for current sustainability challenges and how their relevance could be illustrated and highlighted with examples, which resulted in the list presented here.

Our approach can thus be considered a mixture of what Petticrew and Roberts (2006) refer to as 'conceptual review/synthesis' and a 'traditional review.' A conceptual review is a 'review that aims to synthesize areas of conceptual knowledge that can contribute to a better understanding of these issues' (Petticrew and Roberts 2006, p. 39ff). On the one hand, our semi-structured approach with regard to the literature selection process is in line with more traditional reviews (as in, e.g., Heal and Millner 2014), whereas our approach to review research findings on cognition biases in light of the normative goal of sustainability is a conceptual synthesis.

It is clear that, by construction, our three-pillar approach is biased towards those cognition biases that are well-established in a sense that they have been replicated by different researchers in different settings. In turn, our procedure implies that very recent and potentially relevant findings with regard to risk/uncertainty and inter-group settings were not included.

Finally, it should be acknowledged that the list of human cognition biases presented here is certainly not an exhaustive account of all biases potentially relevant for sustainability, and we think that 'completeness' in this regard would be well beyond the scope of a concise and focused research paper. Rather, we aim at stimulating a line of thinking about (un-)sustainability we feel is quite central for envisioning actionable solutions but currently not—or at least not prominently enough—on the agenda of those interested in contributing to these solutions.

HUMAN COGNITION BIASES AND SUSTAINABILITY: FACTS AND FINDINGS FROM SOCIAL AND BEHAVIORAL PSYCHOLOGY

We present some key findings regarding human behavior and decision making from psychology and discuss them with regard to (un-)sustainable decision making and behavior. The section "Cognition biases on the individual level" presents biases on the level of the human individual, whereas "Cognition biases in group settings" deals with cognition biases that occur exclusively in group settings. We also present possible mitigation strategies and discuss applications that may promote sustainable behavior. Table 1 concludes the section with a concise overview of all biases discussed here.

Cognition biases on the individual level

The following individual-level cognition biases are all in some way about individuals making decisions, in the face of risk or uncertainty regarding what might happen in the future.

Sunk cost fallacy/escalation of commitment

Escalation of commitment (Staw 1976), commonly referred to as 'sunk cost fallacy' in economics and behavioral science, is a human cognition bias towards continuing in the course of some past decision even if the negative outcomes of that past decision become apparent. The tendency to continue grows with the amount of time, money, or effort already spent (Arkes and Blumer 1985). The sunk cost fallacy can be refuted as follows: if the best option to act in a given decision problem is to abandon some project or past decision, then that is true irrespective of past investments or costs incurred, which must be considered lost anyway.[2] What should matter rationally are only the marginal costs and benefits, i.e., what net benefit[3] an option

[2] This is such a fundamental and normatively desirable principle that this is very often assumed as a separate axiom in economic decision theory.

[3] Net benefits are the benefits after subtracting the costs, i.e., sum of benefits minus sum of costs.

Table 1 Overview of human cognition biases relevant for sustainable behavior, together with possible coping or mitigation strategies

Name	Definition	Coping or mitigation strategies
Sunk cost fallacy	The fallacy to include costs already incurred ("sunk") in a decision regarding continuation or abandonment of a project	Raising awareness by education and training of decision makers
		Structuring of decision process by facilitators
Neglect of probability	The non-reaction to changes in probabilities of possible outcomes	Use of decision frameworks incorporating all information available, such as statistical decision theory or expected utility
		Improve communication of risks and uncertainties
		Provide decision makers with statistical training
Zero-risk bias	The overvaluation of choice options that promise zero risk compared to options with non-zero risk and overall greater absolute reduction of risk with regard to the status quo	Put emphasis on total quantities rather than proportions in communication to decision makers
		Highlight opportunity costs of choice options
Default bias	The tendency to stick with the default option in a decision context if such a default option is specified	May be used as "nudge" towards desired outcomes by setting appropriate defaults while maintaining full freedom of choice
Status quo bias	The bias towards the current state of things, i.e., towards the status quo, over possible alternatives	E.g., policy bundling in case of policy options with high societal net present value but large upfront investments
Affect heuristic	A mental mechanism guiding decisions based on the fast, intuitive, automatic, emotional, effortless, and implicit mode of thinking	Joint evaluation of all choice options
		Slight delay of entry into force of policy options to choose from
		Require choice justification in front of others
Group polarization	"The exaggeration through group discussion of initial tendencies in the thinking of group members" (Brehm et al. 2002, p. 272)	Moderation putting emphasis on outcome uncertainty
In-group/ outgroup Bias	Favoring a group with which an individual psychologically identifies over those with which one does not	Moderation and mediation by psychologically trained experts
		Adoption of Rawls' veil of ignorance as reasoning principle
		Moderation should stress uncertain nature of outcomes

to act would create from the moment of decision onwards. The human desire not to appear wasteful has been identified as one possible reason for the existence of this fallacy (Arkes and Blumer 1985; Arkes and Ayton 1999).

The sunk cost fallacy has been used as an important contributing factor to the observed ongoing public and private investment in fossil energy sources in spite of both increasingly available alternatives and uncertain climate impacts (Arbuthnott and Dolter 2013). Janssen and Scheffer (2004) argue that the sunk cost fallacy might have been a key driver for the collapse of ancient societies that built large structures such as the Byzantines or the Anasazi. Similarly, with the help of anthropologic data, Gowdy (2006) promotes the idea that the sunk cost fallacy may be a make-or-break factor with regard to past societies' ability to sustain themselves. Due to its high capital intensity, large upfront investments, and long amortization periods, nuclear energy is particularly prone to the sunk cost fallacy. We argue that further investment in nuclear power infrastructure is a case of escalation of commitment, i.e., continued investment in a failing strategy, even though the effect has proven hard to measure empirically (De Bondt and Makhija 1988).

The best practice to deal with the sunk cost fallacy is raising awareness by training of decision makers, and to have a structured decision facilitation process that points out which costs are sunk and therefore should not play a role.

Neglect of probability

The concept of risk combines outcomes and probabilities; in that, risk is commonly defined as a probability distribution over outcomes (Zweifel and Eisen 2012). Monat et al. (1972) found that people react to a change in magnitude of an outcome, but fail to show a similar response to risk-equivalent changes in outcome probabilities. In other words, the magnitude of an outcome (e.g., the strength of an earthquake, the death toll in a car accident) is something that humans understand intuitively, while its probability is not. Sunstein (2002) named this phenomenon "neglect of probability."

Many problems in sustainability involve fundamentally uncertain scenarios about the distant future, but require action today. The most-debated example is arguably the climate change debate (Sunstein and Zeckhauser 2011).

IPPC scenarios of what might potentially happen in different CO_2 scenarios come as probability distributions over outcomes, many of which are fat-tailed, in that they feature small non-zero probabilities in high-magnitude outcomes (Weitzman 2009). One task of scientists is to get these numbers as good as possible, especially for high-impact low-probability outcomes. While this task is usually pretty tough in itself—quantification of climate sensitivity and prediction of future climate comes to mind—neglect of probability suggests that most decision makers would, inappropriately, think of probabilities as different as 1 in 1 000 000 and 1 in 1 1000 as approximately equivalent, even though the latter is 1000 times larger than the former (Wagner and Zeckhauser 2012). Further examples of sustainability-related issues where the neglect of probability plays a substantial role are the debates about geoengineering as a potential response to climate change (Goeschl et al. 2013; Quaas et al. 2017) and impact and cost–benefit analysis of nuclear energy use and subsequent nuclear waste disposal (Lombaard and Kleynhans 2016).

The problem of probability neglect requires the use of frameworks that capture the available information in a particular decision under risk. Possible frameworks include expected utility theory (von Neumann and Morgenstern 1944; Savage 1954) or, more general, statistical decision theory (Savage 1951; Berger 1985) or analytic philosophy (Parfit 1984). These mathematical frameworks use the available information, break down the numbers, and help to facilitate sensible decisions that adequately account for eventualities and different individual risk preferences. Other important strategies are appropriate communication of probability and risk that takes into account the known human deficiencies in processing probabilistic information along with measures that aim at improving 'statistical literacy' of decision makers (Bond 2009; Spiegelhalter et al. 2011).

Zero-risk bias

In a given decision problem under risk, people tend to prefer the choice option that promises zero risk, even though other options may be better in terms of overall risk reduction (Viscusi et al. 1987; Baron et al. 1993; Rottenstreich and Hsee 2001). For example, when confronted with a decision between act A reducing the risk of a loss from 1 to 0% and act B that would reduce that risk from 10 to 1%, most people would prefer A to B, even though B offers a ninefold higher reduction in loss probability. It has to be pointed out that the failure to distinguish between risks that are objectively quite different—neglect of probability—translates into a failure of adequately valuing risk reductions as in the above example. Thus, the fact that our brain responds to a risk of zero in a very peculiar way combined with the neglect of probability bias leads to the effects described above.

The zero-risk bias is relevant for sustainability in that it implies misallocation of resources to policies that appeal to zero risk instead of policy options that may be far more effective in overall risk reduction, but do not carry the zero-risk promise. Prime example here is the international efforts in the so-called "War on Terror" since 9/11, for which U.S. expenses alone have been estimated to surpass \$4.79 trillion[4] by the end of 2016 (Crawford 2016), while the risk for an American to die from firearms on U.S. soil was more than 1000 times higher than that of being killed in a terrorist attack in the 15-year period since 2001 (Bower 2016).

Baron (2003) suggests that the zero-risk bias can be mitigated by communication of total quantities rather than proportions in decision problems that are concerned with the reduction of risks. Related to that point, we think it may help to stress the opportunity costs of different policies to choose from. In the context of the zero-risk bias, opportunity costs should point out the risk reduction foregone by not choosing to invest in, e.g., climate change mitigation. As with neglect of probability, these suggested mitigation strategies highlight the difficulty of appropriately communicating risk and the need for more care in this regard in future societal debates and political decision making.

Default bias

The fact that people often prefer the default option to other available options in decision situations is called the default bias. It means that if a decision situation is framed such that exactly one option is the default option, i.e., if nothing is actively done then the default option is chosen automatically, then people will tend to stick to that default option, even if another option might be better in terms of expected outcome. The default bias has been prominently documented for the decision to be an organ donor (Johnson and Goldstein 2003). Countries where the default option is to be an organ donor ("Opt-out") have considerably higher participation quotas, up to 99%, than those where the default option is to not be an organ donor ("Opt-in"), where the quotas are between 4 and 28% (ibid.). Similar effects have been reported for resuscitation decisions with newborns (Haward et al. 2012), and the choices between mandatory car insurance policies (Johnson et al. 2002) and different energy providers (Pichert and Katsikopoulos 2008). These examples highlight that the default bias affects many areas of human decision, in some cases even those that involve literal decisions between life and death.

[4] For comparison, the 2015 U.S. GDP was reported to be \$18.04 trillion.

It has been suggested that the default bias may be useful to induce desired behavior or choice without interfering with freedom and liberal values by providing appropriate default options (Thaler and Sunstein 2003, 2009). Examples for such "nudges" in the sustainability context are travel websites pre-checking the "purchase carbon offset" box or printers that come with two-sided printing as default setting (Dias Simões 2016). Furthermore, Milkman et al. (2012) have shown that policy bundling can be an adequate nudge addressing loss aversion in case of policy propositions with high expected societal net present value, which incur some cost or investment in the beginning, and which therefore have a high risk of failing to be passed (Stiglitz 1998).

Status quo bias

Closely related to the default bias is the status quo bias, which stands for a preference for the current state of things over possible alternative states, where the current status quo acts as reference point, and every change with respect to that reference point is perceived as loss (Samuelson and Zeckhauser 1988; Kahneman et al. 1991). Thus, because the status quo bias may work fundamentally against any reform of current state of things, it may consequently work against policy options that propose changes in our current way of living towards a more sustainable future, even if it is clear beforehand that there will be expected net benefits from reform (Fernandez and Rodrik 1991; Eidelman and Crandall 2012). Hence, in a decision between different policy options A (business-as-usual) and B (reform), the status quo bias works towards A and against B, even though B's expected outcome may be better, possibly even by a large margin.

The status quo bias provides an explanation model for the difficulties in the negotiations for a global climate agreement. The current state of things is locked-in as a mental reference point; every concession to the negotiation partners is naturally a deviation from the status quo. Concessions however are formally losses, and these losses weigh twice as much as a possible gain in some other respect, even if that gain is objectively as large or good as the previous loss (Kahneman and Tversky 1979). The result is a perceived overall net loss of negotiating parties, no matter how good or bad the negotiation result may be objectively. Moreover, the status quo bias may have a very strong interaction with biases occurring in group settings, especially with the in-group/outgroup bias and in-group favoritism, since they are both highly relevant for all kinds of group negotiations.

In contrast to the default bias, the status quo bias cannot be used as a nudge towards more sustainable decision making and behavior and should therefore be mitigated. For example, climate negotiations should use strategies that put emphasis on fairness, individual interests, development of mutual beneficial alternatives, and reaching an agreement that is good for all parties involved. Even though the benefit of such principled negotiation methods (Fisher and Ury 1981; Bazerman and Neale 1992) may seem obvious, a strict focus on positional bargaining seems much more common in international politics.

Affect heuristic

The affect heuristic is a mental shortcut, in which a decision is based on the question "How do I *feel* about it?" rather than "What do I *think* about it?" if certain stimuli are present in a decision context (Zajonc 1980; Finucane et al. 2000). Thus, a decision is formed in the "fast, intuitive, automatic, emotional, effortless, and implicit" ("want") thinking system rather than in the "slow, conscious, effortful, explicit, and logical" ("should") one (Bazerman et al. 1998; Milkman et al. 2009). The same person may thus arrive at different conclusions based on the same set of objective facts for a given decision situation depending on whether the "want" or the "should" mode is active (O'Connor et al. 2002). The "want" mode has been suggested to be the main driver of human behavior (Epstein 1994; Finucane et al. 2000).

The want/should duality might be a major factor in explaining the so-called 'value-action gap'[5] (e.g., Blake 1999, Steg and Vlek 2009) in adopting sustainable policies. The value-action gap refers to the observation that while most people agree one should protect our environment and climate; they fail to act accordingly. Furthermore, presence of uncertainty increases a decision maker's probability of preferring "want" over "should" (Milkman 2012). Presenting facts only for persuasion purposes may prevent action, because of lack of emotion (Bostrom et al. 1994; Weber 2006) and strong positive emotions towards a polluting activity may even override any rational risk assessment (Hine et al. 2007). Because emotions are omnipresent, we see affect heuristics as a key lever to societal transformation, especially since many activities that are problematic from a sustainability point of view like, for example, airplane travel are also likely to be linked to positive affective associations (most people use the airplane to go on holidays), which may undermine knowledge about negative impacts (cf. Hine et al. 2007). On the other hand, denial of climate change may be rooted in general feelings of fear (Gifford 2011) or in the reminder

[5] The value-action gap is sometimes also referred to as 'knowledge-action gap' or 'attitude-action gap' depending on source and context (cf. Kaaronen 2017).

of one's mortality it may be evoking (Vess and Arndt 2008).

Possible ways to (re-)activate rational thinking and avoid affect heuristics in questions that require careful and rational efforts rather than fast and myopic answers are to evaluate all options jointly rather than on a one-on-one base (Irwin et al. 1993; Milkman et al. 2009). Joint evaluation refers to the method of setting up a linear model that produces a score based on multiple measurable criteria deemed important for the decision at hand. The resulting score can then be used as a means of comparison between different options in a decision. Another possibility is to make people justify their choices in front of others (Bazerman et al. 1998), or to slightly delay entry into force of policy propositions that are likely to otherwise fall victim to the intrapersonal want/should conflict (Rogers and Bazerman 2008). Kaaronen (2017) has suggested affordance theory as a guiding principle for environmental policy makers that seek to specifically address the value-action gap by looking for ways to systematically provide people with the opportunity to act according to their values. To use Kaaronen's example, a lack of actual recycling behavior may be due to the fact that there are not enough recycling bins in a certain area of interest.

Cognition biases in group settings

Group polarization

If there is moderate agreement among group members regarding an issue initially, group decisions tend to be more extreme than could be expected by its participants' prior individual views regarding a decision to be taken following group discussion. The effect is referred to as group polarization and is more likely to occur when issues the group members consider important are discussed (Kerr 1992). Note that 'more extreme' may not necessarily mean that group decisions are, e.g., always risky. In fact, with regard to risk taking, group polarization can be both towards more risky or more cautious decisions, depending on initial individual views (Isenberg 1986; Aronson 2010). Group polarization has been found to be present even in groups that are concerned with well-balanced high-impact decisions in their everyday professional lives such as politicians (Iyengar and Westwood 2014) and judges (Walker and Main 1973).

Recent data document group polarization over time in the two major U.S. political parties from 1994 through 2014 (Pew Research Center 2014). In international policy, group polarization is considered a major explanatory variable for the lack of inter-group cooperation (Gong et al. 2009). Highly polarized societies are unlikely to come to terms productively with issues that require relatively urgent action, such as most current challenges related to sustainability. Climate change may be argued as a field that has seen growing polarization in the public and political debate leading to ever more extreme positions, heated fights, and relative overrepresentation of rather small but outspoken minorities (Tol 2017). Analyzing ancient Pacific cultures that have reacted differently to sustainability crises (Easter Island and Tikopia), Gowdy (2006) argues that group polarization might have played a significant role in the Easter Island's downfall, because group polarization between competing clans over time perpetuated excessive resource depletion.

It is as of yet unclear how group polarization can be effectively mitigated. Computer-mediated discussion settings have been proposed and tested on small scales, but there is conflicting evidence as to whether these might reduce (Taylor and MacDonald 2002) or even reinforce (Sia et al. 2002) group polarization. On the other hand, many transnational environmental management issues have a prisoner's dilemma structure (Kaul et al. 1999; Young 2011). Evidence shows that the presence of additional uncertainty might heighten inter-group cooperation in prisoner's dilemma-type situations, so moderation that puts emphasis on the uncertain nature of outcomes could help to induce cooperation rather than defection (Gong et al. 2009).

In-group/outgroup bias

People psychologically associate and identify with others according to characteristics such as race, culture, gender, age, religious beliefs, nationality, political preferences and attitudes, or preferences for sports teams. Such in-groups may form within minutes and may also be based on seemingly trivial characteristics such as individual preferences for paintings (Tajfel 1970; Tajfel et al. 1971). Prominent effects related to the in-group/outgroup bias are in-group favoritism, i.e., the tendency to discriminate in favor of in-group members over outgroups, a tendency reported for many cultural areas in the world (Capozza and Brown 2000), and a generally heightened in-group perception of being threatened by the outgroups, which is referred to as outgroup derogation (Hewstone et al. 2002). In-group favoritism is thought to be stronger in individualist cultures than in collectivist ones, but never entirely absent (Heine and Lehman 1997). Competition is thought to drive the in-group/outgroup bias, which may be with regard to limited valuable resources (Levine and Campbell 1972) or respect and self-esteem (Olson et al. 1986).

The in-group/outgroup bias is naturally present in both national and international politics and may favor or even perpetuate inter-group conflicts. Many, if not all sustainability issues evolve around, or are driven by, competing

needs and wants of different groups. Therefore, we find the recognition of the in-group/outgroup bias as pivotal for sustainability. In fact, what Bazerman (2006) refers to as "egocentrism" is a variety of in-group favoritism in practice: in-groups seek to gain esteem by interpreting information in a self-serving way and concluding accordingly (e.g., "The others need to do more than us."; "It isn't our fault."; "We have done enough."). As a consequence, national (i.e., the respective in-group's) interests are overly stressed as important while those of the others are marginalized. As Bazerman (2006) finds this mode of thinking leads to the unproductive scenario that first-world countries blame emerging countries for burning too much fossil fuels while emerging countries blame the first world of trying to deprive them of their legitimate rights to use their natural resources. The problematic message is that even if some country is honestly interested in a fair solution to some transboundary environmental or sustainability issue, the in-group/outgroup bias will lead to self-serving interpretation of information and a perception of being somehow threatened by others, resulting in a less-than-optimal overall outcome.

Indeed, diffuse feelings of threat, which directly result from in-group/outgroup thinking, can have large impacts. Hoffarth and Hodson (2015) showed that the belief that environmentalists represented a threat to a certain way of life, customs, and traditions largely explained the left–right political polarization on the issue of climate change in a U.S. sample, and way more so than did the concern for jobs, which is usually given as the prime argument against better environmental protection in political debates. In much the same way, U.S. meat eaters who expressed right-wing political sentiments had a heightened perception of being threatened by vegetarians/vegans, which largely explained their increased consumption compared to left-wing meat eaters, whereas differing concerns for animal well-being did not matter (Dhont and Hodson 2014).

The above findings make strong a case for the relevance of the in-group/outgroup bias for sustainability challenges. There is however a couple of strategies, which might help in dealing with it. Essentially, the bias supports the call for a novel, more holistic approach to Earth system governance, particularly a global democratic institution that focuses on planetary stewardship by pointing out all humans are in one boat (Biermann et al. 2012). It would have to be a defining goal of such an institution to promote the idea of humanity as one's in-group rather than nations or interest groups. This point seems trivial, but institutional change would require a long time and need considerable political, social, and monetary resources. In addition, as with group polarization, stressing uncertainties in possible outcomes in sustainability challenges that have a prisoner's dilemma structure might also mitigate the in-group/outgroup bias. Lastly, Rawls (1971) suggested a hypothetical situation where people negotiated a social contract without knowing any of their particular characteristics (gender, race, wealth, and so forth). One principle that follows from Rawls' position that could be practically applied is the maximin rule. International agreements should be to the maximum benefit of the worst off party. In today's representative democracies, where politicians are expected to guard and represent national interests, this seems illusory and would require a drastic change in paradigm.

SYNTHESIS AND REFLECTION: TOWARDS MORE SUSTAINABLE DECISION MAKING AND BEHAVIOR

We synthesize six take-home messages from our review of the role of human cognition biases for sustainability from an overarching perspective. The first three of these take-home messages are, more or less, straightforward consequences from what we have laid out in the previous section, the latter provide more general reflections and cross references to related concepts not previously discussed.

Take-home message #1: Biases in group settings play a key role for sustainability

We are not the first ones to bring up the issue of human cognition biases in the context of sustainability. In particular, Hoffman and Bazerman (2007) and Shu and Bazerman (2010) have discussed the role of what they refer to as egocentrism in environmental decisions, particularly regarding climate change. Individual egocentrism, they argue, would lead to egocentric judgments of what is fair. However, we see environmental (mis-)management and unsustainable development predominantly as a problem arising in inter-group situations, such as the management of international fisheries, transnational pollution, and the use of Earth's atmosphere as carbon sink. In such situations, it is in-group favoritism that drives egocentric, self-serving group behavior. Of course, this does not challenge the presence of individual egocentrism as such. Individual egocentrism is the driving force behind the classic idea of the "Tragedy of the Commons" (Lloyd 1980 [1833]). However, because of the inter-group structure of most sustainability issues, we think that a major mechanism at work is in-group favoritism. Arbuthnott and Dolter (2013) make a short allusion to group decision making, but do not follow further the path of using group decision making as an important explanation for bad environmental decisions in general, but only as an explanatory factor to heightened escalation of commitment in fossil fuels.

Undoubtedly, both individual level and group level biases are relevant for sustainability. Political and societal decisions are usually shaped by group processes, whereas market outcomes that reflect consumer choices are mostly the result of individual decisions.

Take-home message #2: Education of decision makers and choice architecture need to be integrated for better decisions

One of the key questions arising from our discussion of the role of human cognition biases for sustainable behavior is: Should one educate decision makers better to avoid biased decisions altogether or should one even use these biases to 'engineer' better results? Contributions such as Milkman et al. (2009) and Gifford (2011) propose the former while Shu and Bazerman (2010) find the latter approach, the so-called "choice architecture" (Thaler and Sunstein 2009), more promising.

However, we propose a best-of-both-worlds approach as potentially most convincing. Biases like zero-risk or neglect of probability can only be cured by statistical training of decision makers. Phenomena like group polarization and groupthink need to be tackled by eliminating known promoting factors and by raising general awareness for these issues. For example, moderation and mediation of group meetings by a psychologically trained external facilitator might help create the environment for better group processes and decisions. Such professional supervision is, for example, common practice in German psychiatric departments, but mostly lacking in academia, the private economy, and politics.

Raising awareness for biased decision making in general is an important measure as well. The focus on the so-called human factors in aerospace is a good example of how raising awareness combined with formal training in coping and mitigation strategies lead to better results (Federal Aviation Administration 2009; Moriarty 2014). Checklists also are a proven-to-work tool in complex environments and decision situations (Gawande 2010). On the other hand, nudging and choice architecture have been demonstrated to work well in a variety of situations, such as in the decision to become an organ donor (Johnson and Goldstein 2003), voting between environmental protection policies (Rogers and Bazerman 2008), the promotion of food waste recycling (Linder et al. 2018), and generally in situations with trade-offs and overall benefits (Milkman et al. 2012).

Take-home message #3: Beware of emotions and respect mental basic needs

The discussion of the role of human cognition biases and hence psychology in sustainability and environmental management also sheds light on the central and important point of motivation. Instead of overly criticizing our current lifestyle by a largely alarmist rhetoric, people and policy makers concerned for the environment should stress the *benefits* of environmental protection and sustainable environmental management (Skinner 1987), and analyze for and make use of potential positive feedback loops within the system (Kaaronen 2017). The underlying logic is a basic psychological fact: positive messages and reinforcement of desired behavior are far more effective than making people feel bad through negative framing or even punishment of unwanted behavior. This has long been established in motivational psychology, and has found its way into our lives as parents, dog owners, or sports trainers, but seems to leave environmentalists, politicians and other societal actors mostly unimpressed. The example of the affect heuristic should teach us to never underestimate or dismiss the role of human emotions in practical decision making.

Another important observation is that one should be aware of the mental basic needs that may drive and perpetuate human cognition biases. For example, according to Social Identity Theory, the in-group/outgroup bias is driven by the human mental basic need for self-esteem (Tajfel and Turner 1986). Mental basic needs should not and cannot be ignored or dismissed by societal actors concerned with sustainability. There are many historical examples of policies or entire political systems not able to pass the test of time, because they did not account for people's mental basic needs such as personal freedom, self-efficacy, or striving for individual fulfillment. Much rather, decision and policy making should be re-designed so that these needs can be accounted for, e.g., through participatory settings (cf. Marcus et al. 2016), without standing in the way of sustainable development.

Take-home message #4: It is not about theory vs. practice but about theory and practice

Decision scientists have long been arguing about how their findings should be interpreted and applied. Gilboa (2010, p. 4) notes a separation of scholars into two groups: Proponents of the positive view that theory should be brought 'closer to reality' on the one hand and proponents of the normative view that theory should inform decision making to bring 'reality closer to theory.' We think that both positions are too extreme. There are facts we can use from theory and facts we can learn from practice. Strict dogmatism is rarely productive. What is most productive is an integrated combination of deduction and induction.

As to what can be learnt from theory, many of the current sustainability issues can be understood and mitigated using tools and models economic theory readily provides. Examples of such models and tools include

externalities and market failure, high discount rates due to large uncertainties, prisoner's dilemma-type situations in negotiations, or open access to resources (Hanley et al. 2013). Solutions within this approach are, for example, privatization of resources, taxing carbon emissions, and installation of international superstructures like United Nations or the European Union for management of natural resources and enforcement of rules and regulations. These insights should be used to inform decision making.

On the other hand, the concepts of choice architecture and nudging are based on reoccurring patterns in decision making practice. These concepts try to exploit decision makers' irrational behavior to steer them towards welfare-optimizing outcomes. Such "libertarian paternalism" strategies (Thaler and Sunstein 2003) are good examples for mechanisms that are inspired by decision making practice that can just as well play an important role in achieving better outcomes.

Take-home message #5: Beware of the fallacy of the single cause

One of the most striking lessons from history is that large disasters are usually caused by a perfect storm of mishaps rather than one single isolated failure or system breakdown. Disasters such as the 1912 sinking of the Titanic, the so-called "successful failure" of Apollo 13 in 1970, or the sudden disappearance of Air France Flight 447 over the Atlantic Ocean in 2009 exemplarily illustrate this point. Applied to the role of human cognition biases for sustainable behavior, we have to conclude that while one should acknowledge that one single bias can definitely do a lot of harm on its own, it should be the concatenation of and interactions between biases we have to watch out for most, because they are likely to play the major role in the formation of large-scale crises that will be caused or further worsened by unaltered human behavior.

However, this message does not imply that addressing single biases is worthless or a waste of time. Much rather, we should start raising awareness for possible interaction effects of these biases. After all, reducing the likelihood of occurrence of single biases will also reduce the probability of potentially destructive interactions. Further research is needed that specifically looks at the interplay of human cognition biases in decision making, so as to better understand how these interactions may contribute to the formation of potentially catastrophic outcomes on a large scale.

Take-home message #6: Cognition biases as leverage points

The systems thinker Donella Meadows identified 12 'leverage points': places to intervene in complex systems where relatively small interventions can lead to systemic changes (Meadows 1999). In the context of sustainability, Abson et al. (2017) argue that these leverage points range from relatively 'shallow' to 'deep' interventions. Where shallower interventions (such as changing incentives or tax rates) are theoretically relatively easy to make, but are likely to have limited transformative potential and deeper leverage points (such as changing the rules of a system or the mindsets out of which a system arises) are more difficult to lever, but are likely to lead to more profound transformative change.

If cognitive biases are a systematic cause for the failure to achieve more sustainable outcomes, then explicitly addressing such biases may lead to multiple leverage points for transformation towards sustainability. For example, the failure to provide suitable taxes, subsidies, or standards in relation to sustainability challenges such as climate change may, in part, be driven by cognitive biases such as the zero-risk bias, or neglect of probability. Tackling such biases may facilitate the 'shallow,' but crucial, interventions. Simultaneously, addressing cognitive biases such as the sunk cost fallacy can be considered as a deep leverage point, as it relates to the mindset out of which unsustainable systems arise (the second deepest of Meadows twelve leverage points). Moreover, knowledge production and use are considered deep leverage points (Abson et al. 2017) and concepts like co-production of knowledge are seen as key in addressing sustainability challenges. (e.g., Lang et al. 2012). Addressing of cognitive biases in group settings is likely to be key in such knowledge co-production processes as it would affect not just who creates knowledge, or how it flows within sustainability decision making processes, but also the systemic problems associated with such multi-stakeholder knowledge and decision making systems.

Perhaps more importantly, addressing group cognitive biases requires challenging the dominant paradigms that constrain and shape decision making processes. This may include considering alternatives to the nation state as the default actors in addressing global sustainability challenges. In turn, this also suggests the need for new designs and rules for international decision making processes that seek to minimize group polarization and in-group/outgroup bias. Doing so may lead to fundamental changes to the way sustainability problems are defined and addressed: from managing conflicting goals among individual self-interested parties (e.g., the Tragedy of the Commons) to creating shared visions of just and sustainable outcomes for all.

CONCLUSION

There are plenty of situations and contexts in which humans tend to deviate from rationality. Some of these

human cognition biases are relevant for the issue of achieving sustainability, because they negatively affect the quality of decisions in terms of both intra- and intergenerational justice. While not all cases of unsustainable behavior can be explained by human cognition biases, we suggest that they should be used more prominently in informing sustainable development and related decision and policy making. Particularly, human cognition biases in group settings may be a threat to sustainable behavior that has stayed below the radar of scientists, politicians, and citizens alike. A human factors training for sustainability may help to raise awareness for biases in general and for the intricacies of individual and group settings in particular. Sustainable behavior is more likely if human cognition biases are accounted for.

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