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Perspective

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From niches to norms: the promise of social tipping interventions to scale climate action

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The net-zero transition poses unprecedented societal challenges that cannot be tackled with technology and markets alone. It requires complementary behavioral and social change on the demand side. Abandoning entrenched detrimental norms, including those that perpetuate the fossil-fueled lock-in, is notoriously difficult, preventing change and limiting policy efficacy. A nascent literature tackles social tipping interventions—STI, aiming at cost-effective disproportionate change by pushing behaviors past an adoption threshold beyond which further uptake is self-reinforcing. Intervening on target groups can greatly reduce the societal cost of a policy and thus holds promise for precipitating change. This article takes stock of the potential of STI to scale climate action by first reviewing the theoretical insights arising from behavioral public policy based on applications of threshold models from sociology and economics; then, it assesses the initial evidence on the effectiveness of STI, in light of the outcomes of laboratory and online experiments that were designed to study coordination on an emergent alternative to the initial status quo. Lastly, the article identifies potential conceptual limitations and proposes fruitful avenues for increasing the robustness of STI assessments beyond theory and small-scale experimentation.

One of the causes of inaction on climate change mitigation is the daunting scale of individual, societal, and systemic changes needed to decarbonize our economies. Yet, change is nonlinear[1], and seemingly stable social conventions such as fertility norms, expectations about gender roles in the workplace, and tolerance for smoking in public spaces are being quickly overturned by the efforts of committed minorities[2–4].

A fundamental question relating to social coordination on large-scale transformations such as global decarbonization efforts is under what conditions can climate action be rapidly scaled up. Addressing it is critical since the targets of the Paris Agreement are now beyond the reach of incrementalism. Only rapid, radical emission cuts can close the gap to avoid warming over 1.5 °C by the 2030s[5], a threshold above which dangerous tipping points may be triggered, such as the collapse of the West Antarctic ice sheet and the destabilization of the Greenland ice sheet[6].

Behavioral change is a key mitigation strategy since demand-side options have a high mitigation potential[7]. Yet, it has only recently started being discussed in the literature, compared to traditionally studied supply-side solutions. While behavioral change needs to be supplemented by supply-side policies such as technology mandates and pricing of the external costs from fossil fuels' use[8], achieving decarbonization within this century requires rapid and widespread citizen involvement. But how much difference can individuals make? According to ref. 9, a change towards climate-friendly behavior by citizens can reduce greenhouse gas (GHG) emissions substantially: up to one-third of the total EU mitigation target pledged for the Paris Agreement can be saved with behavioral change. A similar magnitude (about 20 pct savings) is found in ref. 10.

Yet, operationalizing systemic change at scale is difficult, given the well-known diversity of individual and group responses and the political costs of implementing paternalistic regulation. Furthermore, mass behavioral change might be undesirable as it shifts the burden from producers to consumers, reducing decarbonization efforts upstream. Targeting well-selected groups can circumvent this conundrum by promoting a gradual process that does not exempt fossil fuel producers from their responsibilities while maximizing the speed of change within politically feasible boundaries. Given the above, this article focuses on the promise of targeted demand-side interventions to accelerate change towards low-carbon choices.

To this end, we draw from established insights from behavioral economics and from a new and rapidly expanding literature that explores the concept of social tipping. According to Milkoreit "tipping points in general can be defined as the point or threshold at which small quantitative changes

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in the system trigger a non-linear change process that is driven by system-internal feedback mechanisms and inevitably leads to a qualitatively different state of the system, which is often irreversible"[11]. This general definition applies both to natural and social phenomena. Here, we focus on the latter. Recent examples of (likely) social tipping in renewable energy technology adoption include solar energy[2,12,13], as well as electric vehicles and offshore wind[14]. In the domain of individual choice, Copenhagen has been credited to have transitioned away from driving to cycling around 2018, with about as many cyclists as drivers crossing the city center[15].

Specifically, this perspective is concerned with social tipping interventions (STI), actions such as policies and nudges aimed at triggering self-reinforcing surges in support of decarbonization (henceforth referred to as climate actions). Figure 1 sketches how STI work: a targeted "kick" (i.e., the intervention) destabilizes the status quo and drives the system into an alternative stable equilibrium, leading to disproportionate and possibly irreversible changes. An important specificity of the work on social tipping is thus its focus on deliberate interventions aimed at desirable change[16]. Successful STI intentionally promote contagion with targeted interventions that have the potential to not only instigate change among the target but also among the susceptible untreated population.

Such features make STI particularly appealing to stimulate climate action. This is likely to be an important contributor to the exponential growth in the use of the concept of social tipping in the social sciences[16]. Furthermore, the appeal of STI is likely reinforced by their reliance on circumscribed, targeted interventions to achieve cost-effective and scalable climate action with significant potential[17,18]. Demand-side interventions, including those aiming at tipping, are also less contentious and less vulnerable to political opposition and watering down by vested interests than traditional price and quantity measures to curb supply-side emissions. For instance, taxation tends to be met with resistance when the sanctioned behavior is widespread and legitimized (normative). A well-known example is the outcry that followed the fuel tax increase in France in 2018, sparking the Yellow Vests Protests and leading to the tax cancellation. Such "carbon tax aversion" has been found even for tax and dividend policy proposals whose revenues are entirely redistributed[19]. However, the COVID-19 pandemic has demonstrated that norms and conventions can be quickly destabilized by an unforeseen event, highlighting the malleability of behavior and the potential for swift overturning of unsustainable practices.

Importantly, attitudes and opinions are characterized by alternating periods of inertia and rapid transition[20,21]. Examples of recent dramatic shifts include attitudes towards same-sex marriage, climate change beliefs in the US, support for plastic bans in the EU, and the global rise of the *Fridays for Future* mobilization. On the other hand, examples of lock-in also abound, e.g., unsustainable built environment and extractive sourcing of non-renewable resources, as well as poverty traps. Both stagnation and rapid change can thus be seen as potential societal outcomes, with social norms and beliefs playing an important equilibrium selection role[22]. A successful transition away from fossil fuels is thus likely to hinge as much on policies as on expectations (and on the interaction among the two).

To fix ideas, let us consider the effect of a subsidy to incentivize households' uptake of renewable energy by making it more affordable, although still more expensive than a tariff based on a mix of fossil fuels. It will certainly increase the uptake of the green tariff, but the effect may be limited insofar as the tariff gap is still sizeable. However, an additional intervention might boost adoption by addressing two well-documented behavioral tendencies: pluralistic ignorance ("a situation in which the majority privately rejects a norm, but individuals go along with the norm because they believe incorrectly that most others accept it"[23],) and conditional cooperation (the common tendency "to contribute more to a public good the more others contribute"[24]).

Their joint effect is likely to hinder a conditional cooperator from switching to renewable energy, as she will be inclined to think that others are not willing to act, thus reinforcing the status quo. A further impediment comes from unobservability: sourcing renewable electricity is a private choice that is invisible to others. Insofar as many people care about what choices signal about themselves[25] and are conditionally cooperative, lack of visibility will hinder the adoption of green tariffs by reducing both the share of image-concerned early adopters and the scope for imitation by conditionally cooperative followers[26,27]. Both channels (increased adoption and diffusion via imitation) are shut, compared to a visible behavior such as cycling or driving an electric vehicle.

The above issues apply to the many more climate-relevant decisions that are characterized by limited visibility, including offsetting CO2, avoiding short-haul flights, and switching to a vegetarian or vegan diet. The ensuing risk is being trapped in the high-carbon, low-adoption niche. Clearly, the government and other agents of change, such as educators, NGOs, and firms, have a prominent role in steering society away from high-carbon traps. Somewhat reassuringly, social forces working against pro-environmental change can switch to working in its favor[3]. For instance, Andre and colleagues find that correcting misperceptions about fellow citizens' willingness to act against climate change increases donations to a climate charity by a representative sample of US individuals[28].

One way to frame the issue of the ecological transition is thus in terms of shifting malleable normative views. Since the ecological transition can be viewed as a large-scale social coordination problem, success in overcoming it depends on expectations about future climate policies, technological development, and, more broadly, about the pace and trajectory of decarbonization by actors at micro, meso, and macro scales. Put differently, behavioral change does not take place in a vacuum. It hinges on interdependent beliefs about the state of the world and the actions of others[29].

This is where STI come into play. Whether due to technological, economic, or social reasons, tipping hinges on coordination since the value to one adopter increases non-linearly in the share of adopters[3]. The concept that critical transitions can occur in complex systems was developed in ecology but illuminates many social phenomena in which one is more likely to adopt a behavior the more prevalent it is[20]. Once the tipping point is reached, the actions of a minority group trigger a cascade of behavior change that rapidly increases the acceptance of a minority view[30–32].

In the next sections, we assess the theoretical implications and initial empirical evidence in support of the claim that STI can precipitate change and scale up climate action. We begin by positioning social tipping in the broader literature about tipping points (TP).

Tipping in the literature

TP have been used to describe various phenomena across diverse domains in the natural sciences, notably in earth system science, ecology, and climate modeling[12,33–37]. Figure 2 provides a qualitative representation of different TP concepts' usages over two domains—in the spirit of refs. 11,38—the natural sciences and the social sciences.

In the natural sciences, particularly in studies focusing on the climate, there has been a shift from traditional perspectives that assumed quasi-linear relationships (for instance, between GHG accumulation and global temperature rise) to considering non-linearities triggering abrupt changes, as in the case of the Antarctic ice sheet or the Amazon rainforest area[39–42]. Accordingly, the concept of ecological tipping points (ETP) is now widely recognized in climate science. In the social sciences, and particularly in economics, a longstanding tradition of experimental studies utilizes the concept of TP in its "ecological" sense, referring to it as "thresholds". These works usually model ETP as the contribution thresholds to public goods—for instance, embodying low-carbon alternatives—that must be reached to allow for the production or enhancement of the collective benefits[43,44], or to avoid potential disasters[45–54].

Social scientists have also begun to explore the dynamics leading to crossing social tipping points (STP)—focusing on tipping behavior within social-ecological systems—whether in the presence or not of ecological thresholds. While the literature on ETP has experienced widespread popularity across multiple disciplines particularly after 2000, social tipping has been featured in a relatively more recent body of work[11]. While ETP are predominantly discussed in the natural sciences, the distinction between the two is less pronounced in the social sciences, where many experiments often

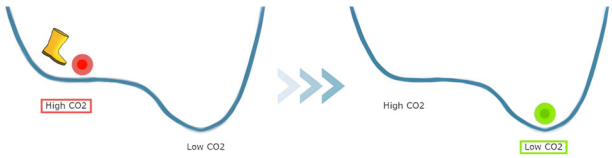

Fig. 1 | An example of how Social Tipping Interventions work in the case of CO2 emissions. A targeted intervention (the "kick") destabilizes the status quo (High CO2) and drives the system into an alternative stable equilibrium (Low CO2).

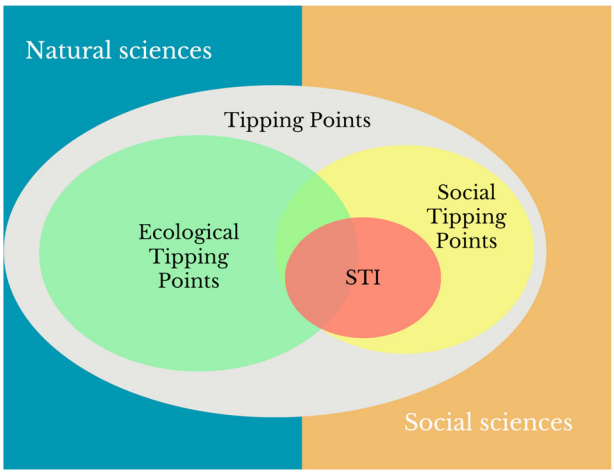

Fig. 2 | Tipping points in the literature. The different concepts of Tipping Points are represented over two domains: the natural sciences and the social sciences.

explore the interaction between social (strategic) behavior and the threat of disasters represented by ETP. Hence, these social science studies (e.g., ref. 55) belong to the intersection between ETP pertaining to climate change and STP related to human behavior. We sketch such features in Fig. 2.

Within the STP literature, increasing attention has been devoted to the prospects of deliberately triggering social tipping through targeted interventions[18,56]. STI are characterized by the introduction of an exogenous change, a "kick" to the system aimed at destabilizing the status quo (for instance, through a new policy). Such intentional shock to an initially stable equilibrium sets STI apart from endogenously-driven changes that happen spontaneously at the population level. Noteworthy studies cover examples of the latter phenomena on a variety of issues from species conservation to cultural practices[4,57–60]. STI are studied in a narrower literature typically concerned with accelerating pro-environmental behavior change.

Social Norms

Much of the work on STI stems from recognizing that social norms can serve as a mechanism to alter behavior even at a large scale[3]. This links the literature on STI to the literature on social norms. The impact of social norms on individuals' behavior has been formalized in various recent works, for instance in[61–64]. For a review of the different formalizations, see ref. 65. While other types of norms—such as unconditional beliefs regarding what is right to do—have been found to also play a role in shaping collectively beneficial individuals' decisions[66,67], social norms—i.e., what individuals believe others do or consider the right thing to do[29,68]—are arguably more amenable to change[69–71]. Thus, suggestions for operationalizing STI often rely upon the idea that social norms in support of climate action can be "exogenously" seeded through targeted interventions to create widespread change.

Norm-based interventions operationalize this idea. For instance, some studies explore the effectiveness of norm-based interventions in promoting sustainable behavior regarding fishermen's management of natural resources[72], households' energy consumption[73–75] and households' residential water use[76]. This literature points to the potential of promoting individual climate action by giving prominence to otherwise invisible green choices[23,77]. For a review of the different social norms interventions for increasing pro-environmental behavior, we refer the reader to[78].

While social norm interventions and STI both aim to promote behavior change through social influence, they differ in approach and scope. Norm nudges leverage social norms to encourage individuals to conform to the perceived norms of a community, providing information about others' behavior or emphasizing social expectations. STI target tipping points within social systems to achieve larger-scale behavioral changes, by mobilizing targeted individuals with the aim to initiate a cascading effect that leads to widespread and persistent adoption of new behaviors or ways of life.

Threshold models of collective behavior

Threshold Models (TM) have a long history in social science and offer valuable insights into understanding collective behavior when individuals behave in ways contingent on one another, as is the case in many observed social dynamics, including riots, epidemics, migration, voting, and strikes[30,31,79–82]. They are particularly attractive due to their ability to explain complex phenomena straightforwardly when agents—who are generally assumed to maximize their utility—have to choose between two possible actions (typically, one representing the status quo and the other an alternative action), with the costs and benefits of each depending on how many other agents choose which action. Hence, each individual in a TM is characterized by a threshold value—ranging from 0 to 100—representing the proportion of others who must take a certain action before that individual is motivated to follow suit. The weaker an individual's conviction in changing to the alternative, the higher the share of others needed to trigger the individual's decision to switch. These models thus build in conformism and the ensuing inertia in abandoning an entrenched norm.

TM allow for high levels of heterogeneity with minimal informational requirements[17,83]. Accommodating threshold heterogeneity is a crucial advantage of these models. In fact, an important feature of TP for behavioral change is that they are likely to be idiosyncratic and vary substantially across individuals[28,84]. By considering the exact distribution of thresholds, TM enable the calculation of equilibrium outcomes in social dynamics[83,85]. Depending on the shape of the distribution of thresholds, different predictions of the equilibrium outcomes can emerge. Figure 3 depicts an example of thresholds bimodally and symmetrically distributed around 50%, in the left panel, and the respective cumulative distribution function (CDF), in the right panel. The 45-degree line shows the proportion of people whose threshold is met at any given point. When the CDF is above the 45-degree line, there are more individuals in the system choosing the alternative action than those that are needed. In the case depicted in Fig. 3, the CDF crosses the 45-degree line from above at 50%: at this point, the population converges on a stable equilibrium independently of initial conditions.

More recent refinements offer a network-based microfoundation for understanding STP by incorporating features from network cascade models[32]. Another fruitful avenue to extend this literature is to focus on the role of different "basins of attraction" in catalyzing cooperation and on analyzing the ensuing dynamics. Evolutionary Game Theory can be helpful, as it is inherently designed to study the evolution of cooperation, emphasizing off-equilibrium behavior[86]. A step in this direction is represented by ref. 87.

Experimental evidence on social tipping interventions

Experimental research on STI is a growing study area. Early work in this field combined theoretical models with online experimentation involving a coordination game—a social interaction in which all agents face the incentive to match strategies[88]—in a population with homogeneous preferences[89]. They investigated the coordination dynamics in reaching a critical mass by introducing a "committed minority" of stubborn actors (bots) that always switched to the alternative choice, even when it was disadvantageous. The fraction of committed bots ranged from 15% to 35%.

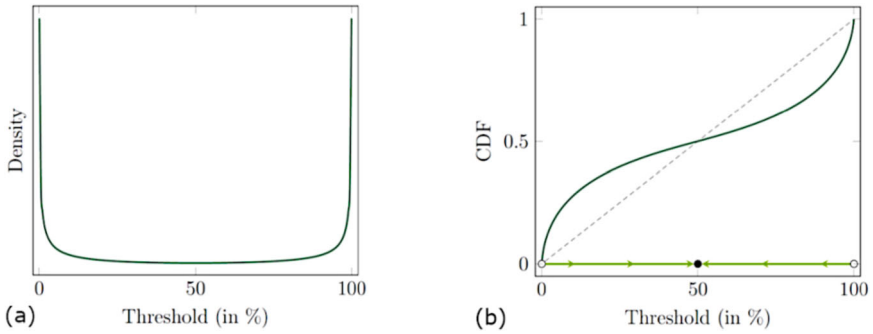

Fig. 3 | An example of threshold distributions. The distribution of thresholds is represented in panel (**a**) and the respective cumulative distribution function is represented in panel (**b**). The example is adapted from ref. 85.

The main finding in ref. 89 was that when the size of the committed minority reached 25% of the population, tipping occurred, and the minority group succeeded in changing the established social convention.

A lab-in-the-field experiment was later conducted in university cafeterias, with an intervention based on promoting the use of reusable mugs instead of one-way cups[90]. The results of this study indicated that real-world environmental dilemmas—albeit at a small-scale level—can exhibit tipping.

Other recent studies have challenged some of the findings from earlier research, emphasizing the heterogeneity of individuals in social dynamics and arguing that the assumption of homogeneity might have led to underestimating the critical mass required for tipping[17]. They suggested that the critical mass needed for tipping may vary depending on factors such as the size of the intervention, the target population, and the distribution of preferences within the population.

Other experimental work has examined further aspects, highlighting the importance of group identity in the success of STI[91]. Their online experiment, conducted around the 2020 US federal elections, demonstrated that group identities based on political labels, by adding value to the status quo and detracting value from alternative norms, can undermine social tipping after intervention. Hence, their work suggests that policymakers consider the potential resistance or backlash from certain political groups when designing and implementing STI.

Various factors can influence the efficacy of these interventions. The importance of an iterative design process, careful piloting, and adaptation before scaling up interventions to enhance their efficacy must be considered[23]. This highlights the importance of considering the specific context and characteristics of the target population when designing and implementing STI.

The promise (and peril) of social tipping interventions to scale climate action

Practical applications

Is behavioral change an important driver in the transition away from fossil fuels? To address this consequential question, we examine specific instances of STI that have the potential to deliver large emission reductions.

In certain domains, we are already approaching tipping points, removing the need for intervention. Renewable power, especially solar and wind power, has already matured to the point of being competitive with fossil fuels[92]. Notably, in terms of technological advancements, heat pumps are anticipated to become a significant breakthrough in the near future[93], while super-efficient solar cells are expected to emerge within the next three to 5 years[94]. Similarly, in the transportation sector, there are promising indications of tipping points being reached, particularly with the growing adoption of electric vehicles in major markets like China and Europe[95].

In considering the potential for promising STI, interesting insights can be drawn from ref. 96. They examine companies' measurement of their emissions using primary data rather than the current voluntary reporting based on the industry average. Emissions reporting is expected to lead to a two-stage change: if enough firms switch to voluntary reporting emissions, firms who will not report such emissions will have the reputation of "dirty firms." And, once enough firms switch to reporting such emissions using primary data, firms that will continue to use industry averages as their emission estimates will be perceived as more-than-average polluters. Accordingly, one can expect that past a given adoption threshold, all remaining firms will follow suit and commence reporting their emissions and using primary data. An alternative STI, building on the findings of ref. 97, could involve the widespread implementation of environment-related food labels, providing information about the environmental impact associated with products to increase consumers' awareness. This would lead to a shift in purchasing behavior towards products with a lower environmental footprint. In turn, a growing demand for low-carbon food would encourage firms to adjust their practices to meet this demand. This competition would drive a positive feedback loop, with firms striving to outdo each other in terms of sustainability practices and environmental performance. Ultimately, the widespread adoption of transparent labels to disclose the carbon content of food can be viewed as an STI that, if successful, would shift consumption past a tipping point where sustainable food choices become the norm.

The above example is not only illustrative of the potential of STI to drive transformative change, but also of their potential pitfalls. As shown in subsection 2, social contagion hinges on reaching an increasingly broader consensus on a new behavior or choice, to a point at which further adoption is likely even among the least susceptible to change. But obstacles, whether financial (e.g., higher cost of sustainably sourced and packaged food), behavioral (e.g., inertia), or reputational issues such as lack of trust in the labels due to greenwashing, may slow down and possibly hinder the spread of an emergent climate-friendly norm. More generally, while initial laboratory evidence suggests that a relatively small fraction of the population (about 25%) is sufficient for tipping, field experimental evidence is needed to assess the external validity of this finding and demonstrate whether STI can induce sizeable change towards climate neutrality. A recent field experiment in university cafeterias finds mixed results: different STI either promoted the diffusion or decay of sustainable consumption norms, and for positive tipping to happen a larger fraction of around 50% adopters was necessary[90].

Benefits and opportunities

STI are a promising tool for researchers and policymakers aiming to study and catalyze behavioral change toward more sustainable patterns. Their potential for cost-effectiveness is particularly advantageous compared to traditional policies, which tend to be either costly (e.g., subsidies) or unpopular (e.g., taxes), or both. In terms of cost-effectiveness, for instance, the Inflation Reduction Act is projected to require ~$369 billion in subsidies and tax credits over a decade for renewable energy, electric vehicles, and other initiatives[98], making it the largest climate spending package in American history. While behavioral STI are unlikely to induce comparably large societal changes, they typically cost significantly less, likely orders of magnitude less. Regarding acceptability, these interventions are anticipated to have higher levels of acceptance compared to other measures such as taxes. Additionally, it is important to note that acceptability is not a prerequisite for the effectiveness of STI, unlike a successful tax policy that relies

on compliance. Even in societies where a significant portion of voters align with right-wing populist parties associated with higher levels of climate change denial[99,100], STI for climate change do not require individuals to personally believe in or agree with the desired behavior, given that these interventions leverage social factors such as conformity, image concerns, and conditional cooperation. Interestingly, in a study focusing on a norm-based intervention to promote climate-friendly behavior in the US, a larger positive treatment effect was observed among climate change deniers compared to non-deniers, as well as among Republicans compared to Democrats[28].

Other factors contribute to the appeal of tipping interventions. First, while targeting only specific actors or groups, effective STI will push climate action past the tipping point, the critical threshold beyond which change spreads to the susceptible untreated via an indirect cascade effect, similar to contagion[84]. Hence, in principle, outsized effects can be obtained with relatively inexpensive and circumscribed interventions. Secondly, promising STI entail seeding social norms to trigger self-reinforcing dynamics that amplify desired behaviors. This aspect potentially eliminates the need for continuous intervention, contributing to the efficiency of STI in terms of resource allocation[18]. Third, by leveraging existing social networks, these interventions can effectively spread through interpersonal connections, accelerating adoption[32]. For instance, network topology matters and can be used to promote the diffusion of ideas and behaviors, with recent evidence suggesting that complex contagion is more likely to spread from the network periphery[2]. Furthermore, STI have the potential to generate multiple co-benefits, beyond the primary behavior change targeted (borrowing this idea from, e.g., refs. 101,102), amplifying the interventions' overall impact and contributing to a broader range of behavioral changes.

Challenges and limitations

While the above reasons suggest that targeting and cost-effectiveness are key advantages of STI, it is important to acknowledge that certain factors may influence their effectiveness, such as intervention design, implementation methods, and evaluation frameworks[23]. Also, one must consider that there might be adverse effects of STI: What if the intervention has negative unintended consequences or even triggers a negative spillover or even a backlash?

It is also essential to address several critiques and limitations that have emerged in the literature. One critique that has been raised is the tendency to abuse the concept of STI, as highlighted by Milkoreit, who warns that "seeing the world through tipping-point glasses" may hinder both research and policy advice. Specifically, she suggests that overuse includes premature labeling of social change processes as tipping, as well as lack of evidence for tipping dynamics[16].

Reality checks and caution against excessive hope in the effectiveness of STI are warranted. Yet, it is worth noting that the youth of this field and scarcity of available data means that most of the literature is so far primarily conceptual, so it is to some extent inevitable that many of the papers reviewed in ref. 16 (and here) are somewhat speculative and suffer from lack of robust empirical evidence. Furthermore, a significant limitation in the current state of STI theoretical research is the assumed homogeneity in thresholds in some of the pioneering models used, despite evidence that individuals differ in the degree of conformism and interdependence in beliefs[17]. Such heterogeneity is likely to be especially relevant for climate preferences and actions. Accordingly, recent work has modeled threshold heterogeneity (as in refs. 17,83,85), in contrast to earlier work[89]—where the notion of a critical mass may not have a straightforward meaning if the populations considered were heterogeneous. By accounting for individual differences, such as diverse preferences, beliefs, and positions in the (social) network, TM can provide a more realistic representation of the behavioral patterns involved in STI.

It is also worth noting that, in our view, STI are an important *complement* to traditional policies, *not a substitute*. Many societal issues relating to decarbonization involve coordination. An obvious example is mobility choices such as switching away from ownership of combustion engine vehicles towards alternatives such as electric vehicles (EV), shared mobility, public transportation, or active commuting in cities. While to some extent idiosyncratic, the benefit-cost calculus of such choices is a function of three key aspects: monetary and non-monetary costs (e.g., cost, time spent, and hedonic well-being associated with commuting), others' choices (as they affect, e.g., congestion and safety) and incentives (for instance investments to expand bike lane availability, preferential access to roads and subsidies for sustainable mobility). These intertwined levers tilt the balance between alternative choices, either paving the way or acting as roadblocks toward change.

That is, tipping often hinges on the combined effect of economic considerations, coordination, and expectations about the future, since, due to network effects, the value to one adopter of a green alternative (e.g., biking instead of driving, or driving an EV instead of a combustion engine one) typically increases in the (expected) share of adopters[3]. In such a context, society faces an equilibrium selection problem and may be stuck in the "brown" status quo, even if the "green" alternative is preferable. As argued by Nyborg, "public policy might help move the economy from one equilibrium to another. [...] A potentially important task for environmental policy is thus to help economic agents coordinate in more environment-friendly ways"[103]. This is arguably what happened in Norway, which deployed temporarily generous incentives such as purchase subsidies and access to bus lanes for EV. These incentives are no longer necessary, as the majority of vehicles are now electric, and have been reduced or removed, without concrete risks of a return to the previous equilibrium.

We end this section by mentioning a potential limitation related to social interventions regarding the expected small effect size, given that commonly observed average effect sizes in norm-nudge interventions are not large, with magnitudes such as the 1.4 percentage point effect documented in ref. 104. Despite the small magnitude, these effect sizes can be significant in achieving climate change objectives through STI, given that the ensuing costs are generally very low and relatively easy to scale up.

Future research

The study of STI is still in its nascent stage, offering numerous opportunities for further investigation that can enhance our understanding of social tipping and the interventions' effectiveness. Figure 4 summarizes the most relevant open questions that we hope can be answered in future work. A crucial area for future research lies in developing an incentive-compatible method to measure individuals' thresholds. Such a method would enable a more comprehensive understanding of the factors influencing tipping points and the degree of individual variation and, more specifically, individuals' readiness to adopt and sustain low-carbon practices. Although the nascent experimental literature on STI has provided valuable insights into the dynamics of STI, little is yet known about the potential of STI at larger scales and in the field. Conducting large-scale randomized controlled trials

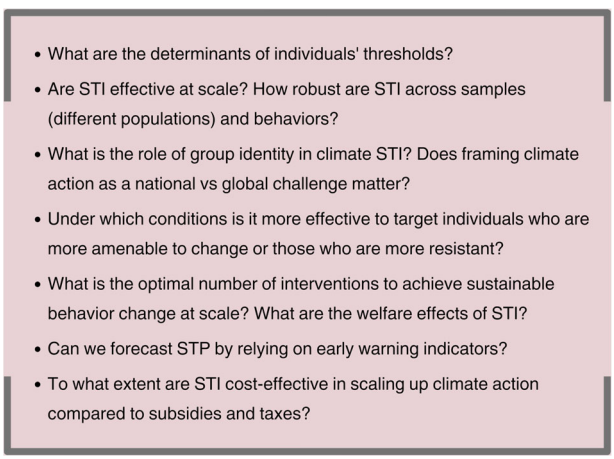

Fig. 4 | Open questions. A summary of open questions within the research on Social Tipping Interventions for climate action.

in the field is to assess the intervention's potential to have a meaningful impact in real-world settings. By implementing STI on a broader scale, researchers can gain insights into the scalability and effectiveness of STI across diverse populations and contexts for achieving climate goals. Moreover, building upon the insights from previous research (e.g., refs. 105,106), future investigations can delve deeper into the role of group identities in STI. This may include studying systems with multiple group affiliations in hierarchical structures[107] or pushing further the study from ref.[91], investigating how political framing can contribute to developing tailored messaging and targeting strategies (e.g., framing climate actions as a global vs national challenge depending on individuals' political orientation[108]). Additionally, the identification of the most effective targeting strategy represents an ongoing inquiry within the STI research. Specifically, assessing whether it is more effective to target individuals who are amenable to change or those who are resistant[17,85] can guide the design and implementation of interventions that maximize their impact on driving behavior change and accelerating global decarbonization efforts. Machine Learning approaches using Large Language Models can also help in targeting with the aim of reducing its cost[109]. Also, the optimal number of interventions remains an open question. Investigating the welfare effects of interventions can shed light on the broader societal implications of STI. Furthermore, there is still a need to empirically estimate how cost-effective STI are, when compared to more traditional supply-side solutions. Lastly, the issue of measurability with regard to both the location of the social tipping point (detection and even forecasting via early warning signals) and the empirical distribution of individual thresholds are key challenges for future work. Some methods, such as the detection of tipping points in the earth systems, are now well-established, but the complexity of social systems poses additional diagnostic challenges[18]. We may, for instance, fail to detect the onset of social tipping even if the process has already started due to the difficulty of measuring emergent social phenomena at the relevant time scale.

Outlook

In this perspective article, we have addressed the following objectives: discussing the tool of social tipping intervention (section 1), reviewing some of the burgeoning literature that is concerned with social tipping, using the lens of behavioral economics of climate action (section 2), and conveying our excitement about STI while presenting the inherent challenges (section 3). We hope that this behavioral perspective will stimulate further discussion and research.

Data availability

We do not analyse or generate any datasets, because our work consists in a perspective piece based on a literature review.

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Competing interests

The authors declare no competing interests.

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