

Addressing global sustainability challenges from the bottom up: The role of information feedback

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Version: January 29, 2012

Abstract

The aim for global sustainable of natural resources confronts our society to a collective action problem at an unprecedented scale. Past research has provided insights in the attributes of local social-ecological systems that enable effective self-governance. In this paper we discuss possible mechanisms to scale up those community level insights to a larger scale. We do this by combining insights from social-psychology on the role of information feedback with the increasing availability of information technology. By making use of tailored social feedback to individuals in social networks we may be able to scale up the strengths of self-governance at the community level to address global sustainability challenges from the bottom up.

Keywords: collective action, information, feedback, social influence, social networks

Acknowledgements: We would like to thank Hans-Joachim Mosler and Robert Tobias for helpful remarks on an earlier draft of this manuscript. We acknowledge financial support for this work from the National Science Foundation, grant numbers SES-0748632.

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Introduction

Our global society experience unprecedented challenges to achieve a sustainable future. The scale of human impacts on the environment may lead to abrupt global environmental changes (Rockström et al, 2009). For example, climate change has been a topic of international policy negotiations since the early 1990s. At that time scientific studies showed that an immediate stabilization and future reduction of the global greenhouse gas emissions was needed to avoid an average temperature increase of 2 degrees Celsius (Hammitt et al. 1992). Despite various global treaties, the global emissions of fossil fuel related CO₂ have increased more than 40 percent².

Addressing global scale problems from the top-down has not been effective. However, decades of research has shown the abilities of communities to solve collective action problems (Ostrom, 1990). Addressing a global scale problem like climate change requires actions at different levels of scales, including bottom up initiatives, in a polycentric system (Ostrom, 2010). In this paper we emphasize the opportunities of bottom-up processes, but recognize that that initiatives at all scales are needed to address global scale problems.

The study of self-governance of the commons has mainly focused on small scale communities (Ostrom, 1990). Studies in small scale communities and in controlled experiments (Poteete et al. 2010) show the strength of groups in overcoming collective action problems if participants can communicate, have input in the creation of the rules and if institutional arrangements are monitored and enforced. In small scale communities participants have relative low costs in deriving information to determine the trustworthiness of others. This is not the case at a larger scale.

Despite the strength of communities, low hanging fruit of addressing large scale problems are unaddressed. For example, research shows that the national carbon emissions can be reduced by more than 7 percent without new regulation, technology or infrastructure (Dietz et al. 2009). If people take advantage of existing opportunities that can already make a big difference.

Even though there is low hanging fruit, why do individuals not make use of them? To understand this we have to look into the factors that influence individual decision making. A focus on individuals and providing factual information alone is often not effective (e.g. McKenzie-Mohr, 2000). Besides factual information, we have to pay attention to the individual motivations and the social influence on behavior (Olli et al., 2001; Heiskanen et al. 2010). From this perspective, the problem of scaling up insights of small scale experiments depends on our ability to provide the right information of the factual consequences and social context of the individual behavior.

In this paper an attempt is made to blend insights from collective action research and psychological research on behavioral changes, especially the role of information feedback in behavioral change. We expect that the use of social media technology may facilitate such a scaling up. Since social media facilitate feedback of information in social networks, we review what is known about the effects in feedback on behavioral changes.

The rest of the paper is build up as follows. The next section discussed the basic literature on collective action of the commons and relates the empirical findings to the importance of information feedback. The following section discusses the basic findings

² 1990 21.6 Trillion Metric Tons CO₂ and 2009 30.3 Trillion Metric Ton CO₂ according to official statistics (www.eia.gov)

of information feedback, while the subsequent two sections deal specifically with individual and social feedback. The last section concludes the paper.

Collective action and the Commons

In his famous 1968 essay in *Science*, Garrett Hardin concluded that overuse of common resources was inevitable since users would never self-organize. Hardin envisioned a pasture open to all, in which each herder received an individual benefit from adding sheep to graze on the common land and suffered costs only later (and shared with other herders) from overgrazing. Besides private property rights, an intervention such as taxing the use of common resources, is the only possible intervention to avoid overharvesting of the commons.

Ostrom (1990) performed a meta-analysis of case studies on natural resource management. Many communities are able to self-govern their common resources without interventions. Ostrom found that a number of characteristics of institutional arrangements are common in success cases, such as clearly defined boundary rules, conflict resolution mechanisms, monitoring, graduated sanctioning and the ability of users to participate in collective decision making.

The accumulation of studies using various methods to study collective action and the commons led Poteete et al. (2010) to present a framework of collective action and the commons based. Individuals have imperfect knowledge, who learn and adopt norms, and who are influenced by micro-situational and broader contextual variables. Especially important is the notion of other-regarding preferences and conditional cooperation. The majority of participants in controlled experiments are classified as conditional cooperators (Fischbacher et al. 2001). They will cooperate in collective action situations if they expect others will do so too. Smaller fractions of the participant population are identified as egoists or unconditional cooperators. In heterogeneous groups conditional cooperators will reduce their level of contributions to the public good if they see that there are others who do not invest the same level as they do.

The observation that most participants are conditional cooperators explains why communication is so important. Communication enables participants to signal their intentions and trustworthiness. Not only do participants cooperate if they expect that others will, they also value and receive emotional benefits if others receive good earnings too and that the earnings are fairly distributed among the participants.

The work of Ostrom focuses on small communities. There is a convincing amount of evidence that small communities are able to overcome the tragedy of the commons in the right context. They have the ability to develop and maintain trust relationships and monitor behavior of the population. Larger groups will make it more difficult to evaluate the trustworthiness of all other participants and make it easier to free ride on actions of others. The information that one can derive regarding the reputation of others can have an important influence of decision making.

For example, Chaudhuri and Paichayontvijit (2006) show that more detailed information about the decisions of participants leads to an increase of cooperation. The more detailed information provided insights in the level of conditional cooperators within the group. In a similar approach, de Oleviera et al. (2009) first determined whether participants are selfish or conditional cooperative using a one shot public good game. Participants were then sorted in homogenous or heterogeneous groups, and dependent on

the treatment they were told the distribution of others or not. Not surprisingly groups of conditional cooperators led to higher level of cooperation, but the level was higher if this information was known to the participants at the start of the experiment.

Which information is provided to the participants is important. Nikiforakis (2010) shows in public good experiments that providing participants feedback on the earnings of their peers leads to less cooperation compared to the condition where feedback is given on the contributions of their peers. Note that these information differences do not affect the incentive structure.

In public good experiments by Erhard and Keser (1999) and Ahn et al. (2005) participants could choose with which group to participate. The effect on cooperation due to this voluntary group selection is minimal since free-riders infiltrate groups with high contributions. In Page et al (2005) participants could rank every 3 rounds all participants, using the average contributions in previous rounds. Based on the mutual ranking preferences, groups were sorted. They found that this sorting – with mutual agreement - increases the contributions to the public good, even compared to the use of costly sanctioning. Another option is the ability to exclude automatically low contributors as tested by Croson et al. (2006). When low contributors are automatically excluded from benefits of the public good, they find that this largely increases the level of contribution.

The explanation that sorting of participants increases the level of cooperation in the population as a whole relates to the types of behavior participants express. Sorting of participants can increase homogeneity of the behavioral types in groups. Conditional cooperators will remain to cooperate and the level of cooperation will increase in the population as a whole.

Finally, Janssen (2011) performed experiments in a spatial explicit common-pool resource. When participants could see the whole screen the harvesting rate was higher compared to the condition with limited vision. When participants can only see a small radius around their avatar, they may not observe those participants who are more greedy than them and continue to harvest modestly. The effect of information is reversed if we allow communication. With limited vision participants have more difficulty to see whether other participants follow the agreed strategies.

The bottom line is that information about the other participants affects the ability to derive information about the distribution of types of others within the group. More information typically increases the level of cooperation.

New information technologies reduce the costs to communicate with a larger number of people who are not necessarily physically co-located. What will be the implications for collective action situations? Since there has been a limited focus on the potential impacts of information technology on the governance of shared resources, we will explore different areas of research to identify potential impacts. New technologies can deliver accurate information on the consequences of decisions of yourselves and others. Cheap communication tools may also lead to an information overload. These different possible effects may lead to different decisions of conditional cooperators to contribute to the public good. In the next section we will review some basic literature how information feedback affect decisions.

Personal feedback

Feedback is when we provide information about someone or some group's performance so that they may understand the effect of their actions and adjust them to some desired level (Kluger and DeNisi, 1996). In energy use studies for example, providing feedback could mean displaying current energy use to users, this would hopefully lead to a decrease in energy consumption assuming that users desire to use less energy (we will discuss this assumption later in the paper). Below we review what we know about providing personal feedback - feedback about one's performance provided only to that one.

First, feedback must be specific. Early studies that examined home energy-use often achieved no significant results and provided only aggregate energy use data (Seligman and Darley, 1977; Hutton et al., 1986). McCalley and Midden (2002) suggest that these early failures were the result, among other things, of not examining a specific task and providing participants too little data "of precisely how much energy is being used for various purposes" (p. 590). In support of this McClelland and Cook (1979) found that their participants used the feedback monitor "as a learning device to identify which activities... consumed the most electricity [to] adjust their behavior accordingly." Grønhøj and Thøgersen (2010) provided electricity consumption feedback "broken down according to end-uses" to families and found significant reductions in energy use.

McCalley and Midden (2002) continue that for people to be provided information on the precise outcome of their energy use decisions, feedback must be delivered continuously. Referred to in other literature as rapid or continuous feedback, McClelland and Cook (1979) and Van Houwelingen and Van Raaij (1989) found that when feedback is provided at various frequencies the greatest reductions of electricity occur at the most rapid feedback frequencies.

Goal Setting

Though Bandura (1977) wrote that providing feedback strengthens a sense of self efficacy and control, feedback alone will not reduce consumption unless there is an implicit incentive in reducing consumption, as mentioned above. Congruent with this view McCalley and Midden (2002) claim that "[studies] that [do] not engage the [participant] in some form of goal-setting [will] show no success of lowering consumption through feedback." Thus, we introduce goal setting, an intervention where participants can commit to objectives and are thus driven by a sense of progress and accomplishment that incentivizes behavior change. Locke and Latham (2002) explain in their review of goal setting that there are two types of goals, do-your-best and specific goals. Do-your-best type goals yield lesser performances because they "have no external referent ... [and] this allows for a wide range of acceptable performance levels." Locke and Latham recommend explicit, specific, and relatively difficult goals, as they found that "The highest level of effort occurred when the task was moderately difficult, and the lowest levels occurred when the task was either very easy or very hard." Therefore a goal like "I will reduce my energy use by 20%" will yield better results than "I will use less energy." This is supported by Becker's (1978) work on energy use where the condition "difficult goal with feedback" appeared more effective in reducing home energy use than the condition "easy goal with feedback".

Other variables thought to influence motivation are whether one chooses their goal or has it chosen for them. Wright and Kacmar (1994) hypothesized that “a person who is more self oriented will prefer to rely on their own judgment and thus respond better to self-setting a goal and persons who are more socially oriented will respond better to an assigned goal as it represents an expert viewpoint reflecting a socially determined or acceptable norm.” When McCalley and Midden (2002) tested this they found a small, but significant effect, though self-set goals achieved the greatest change overall. It is a possibility, McCalley and Midden write, as Kluger and Denisi (1996) also identified, that personality may moderate efficacy of various goal interventions.

Social Feedback

Here we discuss two theories that explain the effects of providing information about the actions of others on individual behavior. Additionally we discuss goal setting in a social context and the importance of using these various interventions to create communities of behavioral change.

Social norms

By providing feedback on actions of others, one can signal social norms from the community. Such comparative feedback provides individual performance relative to the performance of others (Schultz et al. 2007; Abrahamse et al., 2005). Group feedback makes salient descriptive norms, what is commonly done by others.

Croson and Shang (2008) study donations to charity and use social information about the level of donations of others and self in the past. Those who donated above average in the past reduced their contributions, while those below the average increased their contributions. The net effect was a decrease of donations due to providing social information. A similar finding was found by providing social feedback on energy bills in a study in households in California (Schulz et al. 2007). However, when those who used less energy than average also got a smiley face - ☺ - those households stayed at a low energy use level. Those who used more than average got besides the factual information the icon ☹, and this led to a faster decline of energy use. The lesson from these studies is that the details of how to provide social feedback matters.

The study of Schultz et al. (2007) has been implemented by OPOWER, a customer engagement platform for the utility industry. They work with utility companies to send customers information on how the customer is doing compared to the neighborhood. Allcot (2009) performed an analysis of about 600,000 households of which half of them derived the targeted feedback on their energy bills. The energy savings of about 2% is modest but statistically significant.

In providing social information it is important to provide information of others that are comparable. For example, college students are not very sensitive to social norms of parents nor faculty, but are sensitive to social information of their peer students (Perkins, 2002). In fact, students overestimate the drinking behavior of their peers, and providing factual information about drinking behavior of peers reduces the level of drinking (Perkins, 2002). Similarly, providing information how many guests recycle their towels in a hotel increases the level of recycling significant more than providing factual information (Goldstein et al., 2008).

Social norms can be classified in two categories: injunctive and descriptive. Injunctive social norms refer to people's belief what ought to be done, while descriptive norms just to beliefs what people are actually doing (Cialdini et al. 1990). There is an overlap of these two categories. The examples above are descriptive social norms. An example of the use of an injunctive social norm is given by Gerber et al. (2008). They performed a large-scale field experiment with 80,000 households during the 2006 primary elections in Michigan. Four different types of letters were randomly send out, varying from "It is your civic duty to vote" to "What if your neighbors knew whether you voted". In the last letter it was also mentioned that it is a civic duty to vote and voting turn out of the household and their neighbors of previous years was provided. This last treatment led to a significant increase of 30% to 38% voting turnout.

Social Comparison

Social comparison is another method to explain what happens when an individual is provided feedback on others' behavior. The theory explains that people evaluate their performance by comparing themselves to others (Festinger, 1954). There are two main types of comparisons: upward social comparisons, comparisons to those of higher status, and downward social comparisons, to those of lower status (Suls and Wheeler, 2000). For example, Davis (1966) found that college graduates' career aspirations are moderated by their standing among their peers. Students who succeed at a college where good grades are easy to obtain tend to have higher career aspirations than an equally qualified student at a more competitive school. However, Suls and Wheeler (2000) note that slight upward comparisons can have a motivating effect but an extreme upward comparison can lead to discouragement, while being the highest performer can also lead to apathy (Sun and Vassileva, 2006). For a more comprehensive review of social comparison see Wood (1989). Lastly, Festinger (1954) noted that the tendency to compare oneself with others decreases as one's own ability and opinions become divergent from the comparison group and that when people know others are comparing themselves to them, they seek to be viewed positively and act more responsibly. Therefore, we can motivate participants by facilitating a social context of similar others and the appropriate type of social comparisons.

Goal Setting In a Social Context

The research regarding the effects of goal setting in a social context is conflicting. Hollenbeck et al. (1989) in a 190 participant study concluded that commitment to difficult goals is higher when goals are made public rather than private. Cialdini and Trost (1998) argued that this was a consequence of the need to appear consistent to oneself and others. Lerner and Tetlock (1999) continued that public commitments make the participant accountable to the audience. However, in Gollwitzer et al. (2009) demonstrated how a goal's public declaration can adversely affect progress. Across four studies where participants were working towards goals, half announced their goals and half did not, and consistently those that remained silent made more progress. The group explains that announcing your intentions produces a gratification that reduces striving to accomplish your goal but that a middle ground between these conflicting findings may lie in framing intentions to receive no satisfaction.

Social Network

What is often not discussed in the theoretical feedback and goal setting literature and its applications is the importance of a community of kin and similar others to the participants. McCalley and Midden (2002) found that many feedback studies failed to produce lasting behavioral change because once experimental intervention ceased people returned to old behaviors. Sustainable behavioral change requires building social networks to reinforce the new habits (Staats et al. 2004).

De Young (1996) and Geller (2002) proposed a model of proenvironmental behavior change build upon a supportive social environment, opining that the supportive environment promotes sustainable change by facilitating communication and encouraging participation that reinforces agreed upon norms. Findings that suggest the validity of this idea include Hopper and Nielsen (1991), who in a recycling awareness initiative found that a “block leader approach” to informing neighbors was most effective. Weenig and Midden (1991) found that information about energy-saving appliances from friends and kin were markedly influential in purchasing decisions. And participants in early Stepgreen trials requested plug-ins for Facebook and Twitter, as well as ways to compare their carbon footprint graph to those of their friends” (Mankoff et al., 2009).

Additionally, Burke and Settles (2011) claim that when “people are attached to the group as a whole or to individual members, the outcome is group cohesion... [and] Highly cohesive groups elicit stronger performances.” Staats et al. (2004) applied this model in creating EcoTeams, where groups composed of 6 to 10 people who already knew each other as neighbors or friends were formed to discuss a provided environmental issue on a monthly basis in an attempt to motivate participants to take basic actions to lower their carbon footprint. The researchers found that strong social ties within their EcoTeam “resulted in intentions predictive of proenvironmental behavior change, irrespective of the degree to which habits were consolidated.” Designing close communities is the missing link between stimulating behavioral change and creating sustainable cooperation strategies.

Existing projects on information feedback and sustainability

The research on feedback emphasizes the importance of continuous and personalized feedback, and the positive role of setting goals. These characteristics are increasingly possible with the use of modern information technology such as smart energy meters (e.g. Mattern et al., 2010), smart water meters (Hauber-Davidson and Idris, 2006), tracking locations (e.g. Froehlich et al., 2009), remote sensing (e.g. Hay et al. 2011), and the use of social media.

There are various projects ongoing that provide feedback, especially on the use of energy:

- Ubigreen (<http://dub.washington.edu/projects/ubigreen>) provides people feedback on their mobile phone on their transportation usage based on sensors and activity inference. It provides visual rewards if options are chosen with less environmental impact.
- Opower (<http://opower.com/>) works with utility companies to send energy bills with information of the household energy use compared to the neighborhood. Allcot (2009) shows that this feedback has a significant reduction of energy use.

- Stepgreen (<http://www.stepgreen.org/>) is a website where the user self report activities that lead to sustainable behavior. The user can set goals and share this with friends.
- Tendril Energize (<http://www.tendrilinc.com/>) is an energy management tool where users can set goals and get real time information on the progress. The user also derives information how one compares with peers.
- EnergyWiz (<http://www.urbaninformatics.net/projects/energy/>) is a prototype of a mobile app that provides comparative information on energy use.
- BitstoEnergy lab (<http://www.bitstoenergy.ch/>) contains various projects – such as eMeter, to provide feedback on energy and water use, and provide attractive visualizations on mobile apps and websites.
- People Power (<http://www.peoplepowerco.com/>) – People Power created a smartphone app that works in conjunction with hardware like BlueLine (<http://www.bluelineinnovations.com/>) and TED (<http://www.theenergydetective.com/>) that allows people to view detailed energy use information and share it and compete with friends through social media like Facebook

These applications are mainly focused on providing feedback of energy using smart meters. Except for Opower, the applications have not tested the long-term behavioral effects on energy use. The lack of long-term evaluation is caused by the fact that most applications are available only recently. Nevertheless these examples show that there are many opportunities becoming available to stimulate contributions to the public good with high tech monitoring.

Table 1: Comparison of existing application of information feedback using modern information technology.

	Continuous feedback	Social feedback	Goal setting	Resource	Social network
Ubigreen	Yes	No	No	Energy	No
Opower	No	Yes	No	Energy	No
Stepgreen	No	Yes	No	Carbon Footprint	Yes
Tendril Energize	Yes	Yes	Yes	Energy	No
Energywiz	Yes	Yes	No	Energy	No
eMeter	Yes	No	No	Energy	No
People Power	Yes	Yes	Yes	Energy	Yes

Merging collective action and feedback

The motivation for this paper was to explore whether it is possible to address large scale collective action problems using insights on information feedback and modern information technology. In this section we will discuss the potential synergy of the findings in collective action and feedback research.

The experimental research with small groups on collective action has shown that majority of participants are conditional cooperators. Furthermore, allowing for

communication increases the level of cooperation. Although it is widely accepted that communication has a positive effect on cooperation in collective action experiments, it is not clear what the main reasons are. An important role of communication might be to derive a better idea of the attitude of the other participants. Knowing that others are also conditional cooperators increases the level of cooperation. This is confirmed by just providing information on the behavior in other experiments (de Oliviera et al. 2009).

Providing feedback about the consequences of actions on outcomes does not always lead to a positive effect. However, more effective are the types of feedback where information is given what other persons do. From the perspective of collective action and the commons the effectiveness of social information may indicate that social feedback reinforces the cooperative nature of most participants. Field experiments with large populations show that providing tailored social feedback to individuals can lead to a significant increase of contributions to the public good (Gerber et al. 2008; Allcot, 2009).

One of the challenges society experience with large scale collective action problems is that the policies do not fit with the individual motivation and knowledge to contribute. Ostrom (2010) argues that a polycentric approach is needed for climate change policy where activities that contribute to emissions reductions can be stimulated by incentives at the local level fitting local motivations such as improved health by cycling to work and smog reduction. The importance of Ostrom's argument is to fit the challenge to the motivations of the individual.

In a world where people are increasingly connected by ties in social network sites instead of spatial proximity and kinship, and where activities are increasingly be monitored real-time and spatially located, there might be opportunities to aim global change policies on individual motivations and social contexts.

Discussion

The rapid information technology development makes it possible to derive real-time accurate information on the consequences of our decisions and the decisions of others. Increasingly people participate in various online social networks which make it possible to share and compare information, and connect people with similar interests. This provides opportunities to scale up the strengths of self-governance as is observed in communities.

The opportunities to provide real time feedback on resource use has been implemented in various projects on energy use, and some of them show a statistically significant energy reduction (Allcot, 2009). Energy is a logical starting place due to the availability of smart meters. However, increasingly this kind of tools might be applied to topics like water use, vaccination, footprints of your groceries, recycling, etc.

In this paper we tried to connect the insights from collective action with feedback research. We argue that there are interesting opportunities to test whether the power of small group cooperation can be scaled up using modern information technology.

We are aware of various challenges of such an approach. Although individuals share a lot of their private activities with the public in social media networks, the idea of tracking behaviors of individuals might be a frightening infringement on the privacy of individuals. Probably the most challenging aspect would be to stimulate the use of the new technologies. Car insurance company Progressive, for example, allows customers voluntary to join a program where a device is installed in your car that tracks your driving

style. One can save a significant amount of the car insurance fee with a proper driving style.

International negotiations on climate change led to ambitious treaties, but lacked a significant impact on the trends of emissions. There are opportunities emerging due to low costs monitoring devices that provide personalized feedback to others. Various initiatives are underway, especially related to energy use, to implement such tools in practice. Those applications are promising and need to be studied in detail to enhance our understanding how to scale up the power of self-governance to address global change challenges.

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