Credibility-Enhancing Displays Promote the Provision of Non-Normative Public Goods

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Abstract

Promoting the adoption of public goods that are not yet widely accepted is particularly challenging, because most tools for increasing cooperation – such as reputation concerns[1] and social norm information[2] – are only effective for behaviors that are commonly practiced, or at least widely agreed upon as desirable. Here, we examine the adoption of non-normative (i.e., rare or unpopular) public goods by applying the cultural evolutionary theory of credibility-enhancing displays (CREDs)[3], whereby behavior is more powerful than speech alone when assessing others' beliefs. By this logic, people who themselves engage in non-normative public goods behaviors will be more effective advocates than those who merely extol the behaviors' virtues. As predicted, a field study promoting residential solar panel installation implemented across 56 towns (1.4 million residents) found that community organizers who themselves installed solar panels through the program recruited 38% more residents to install solar compared to community organizers who did not. These results were replicated in three pre-registered experiments using random assignment (total N=1799), which also provided support for our proposed CREDs-based mechanism and demonstrated generalizability to four other highly non-normative behaviors. Our findings shed new light on the challenge of spreading non-normative prosocial behaviors, offer the first empirical demonstration of the power of CREDs for increasing the provision of public goods, and have substantial implications for practitioners and policy-makers.

Keywords

public goods | cooperation | solar power | field studies | credibility-enhancing displays

The provision of public goods—such as the curtailment of climate change and protection of air and water quality—is crucial to human (as well as other species') welfare. Yet it is often difficult to motivate individuals to contribute because of the personal costs involved in doing so[4]. As a result, a large body of work across the social and natural sciences has used formal models and laboratory experiments to identify ways to promote such cooperative behavior[5-8].

Supporting a central conclusion of this line of basic science research, field experiments examining the provision of real-world public goods have demonstrated the power of interventions based on reputation concerns and descriptive social norms for promoting cooperation (for a review, see ref 9). Such interventions rely, however, on most people already contributing to the public good in question (i.e. the existence of a *descriptive* social norm), or at least believing that people *should* contribute to it (i.e. the existence of an *injunctive* social norm)[2,10-14]. Otherwise, there are no reputational consequences for not contributing, and/or reputational benefits for contributing.

A key question, therefore, is how to promote public good-enhancing behaviors when such behaviors are *not* already normative. That is, how can new norms for contributing to public goods be spread? Here, we focus on changing norms from the "bottom-up" through the actions of individuals trying to influence the behaviors of those around them—as opposed to "top-down" approaches based on institutional sanctions or policy change[15]. There is substantial theory[16] and evidence[17,18] that people can indeed help spread norms for the provision of particular public goods within own their communities. A critical challenge for maximizing the success of such efforts is identifying which factors make individuals more or less effective as "cooperation catalysts." In other words: why are some people more successful in their efforts to promote the adoption of new norms related to public goods than others?

Here, we shed light on this issue by leveraging a theory from the study of cultural evolution: *credibility-enhancing displays* (CREDs)[3]. The essence of CREDs theory, which has primarily been used to explain religious commitment[19-21], is the importance of actions for shaping *second-order beliefs* (i.e., what I believe about what you believe). In particular, CREDs theory focuses on actions that are expected to be beneficial to people holding the belief, but expected to be costly to people not holding the belief. If I see you engage in such an action, it provides a signal that you actually hold the belief (and thus think the action is beneficial) – a much stronger signal than if you simply say that you believe it. In the canonical example, one person may try to convince another that a certain type of mushroom is edible[3]. If the mushroom *is* edible, there is a benefit from eating it; if the mushroom is inedible, however, eating it can be extremely costly. An individual trying to learn about the edibility of mushrooms will therefore have much greater confidence in the belief of a "teacher" who actually eats the mushroom in question, rather than one who simply states their belief that the mushroom is edible. Thus CREDs provide an adaptive logic for the idiom "actions speak louder than words."[3]

The logic of CREDs generates a clear hypothesis for bottom-up attempts to promote real-world public goods: advocates who themselves engage in a given cooperative behavior should be more effective at convincing others to also adopt that behavior. Furthermore, we would expect this difference to be driven (i.e., mediated) by the extent to which advocates are perceived as truly believing that the behavior was beneficial – that is, by potential adopters' (second-order) beliefs

regarding the advocate's beliefs about material costs and benefits to self, social costs and benefits to self, and societal benefit.

To test these hypotheses, we examine participation in a community-organized solar panel installation program. Solar panel installation by individuals is a classic example of private provision of an (impure) public good. A socially efficient, optimal population-level solution is achieved via broad adoption of such a clean (i.e., non-fossil fuel based) energy source, because it would curb the tide of increasing atmospheric carbon dioxide and resultant climate change. Yet for any individual home owner, the immediate financial cost of installation combined with the search cost of learning about solar and suitable installers may outweigh any personal benefit, creating a tension between individual and collective interests. Thus, despite attempts to promote the adoption of solar panels (e.g. state and federal rebates and tax incentives for residential solar installation in the United States, which imply that most consumers begin saving money from the installations after only a small number of years[22]), solar installation remains descriptively non-normative (e.g. only 0.3% of American households have residential solar)[23,24]. Similarly, there is not a strong injunctive norm stipulating that people *should* be installing solar panels: in an online norming survey, solar panel installation was rated as being roughly half as injunctively normative as classic strongly normative behaviors such as voting, recycling, or donating to charity (see SI Section 2 for details).

We examine the role of CREDs in community organizers' ability to promote solar panel adoption by utilizing data from the "Solarize CT" campaign, run in 56 towns in the state of Connecticut (total population size 1.4 million) from 2012-2015. The campaign employed peer-to-peer interactions of community members to promote the adoption of solar panels through a group pricing scheme and a limited time-frame grassroots campaign, and has been shown to more than triple adoption rates[25]. In particular, each town had a volunteer "Solar Ambassador" who was responsible for coordinating community outreach for the Solarize campaign and encouraging other residents to participate in the program[26,27]. Ambassadors were primarily recruited from town elected officials, town managers, and members of the town clean energy task forces because they were most likely to be key nodes in the community social network, and thus were more likely to be influential[28,29]. Because the ambassadors were recruited based on their centrality in the community social network, rather than their own solar installation choices, a majority of the ambassadors (67.9%) did not themselves participate in the Solarize program. See SI Section 7 for further details about the Solarize program.

In a field study and two experiments, we ask what made some ambassadors more effective than others at encouraging community members to install solar panels through Solarize. In particular, in the field study we ask whether the minority of ambassadors who had themselves installed solar panels through Solarize were better at convincing others to install, as predicted by CREDs theory. We then replicate the result of the field study using random assignment in Experiment 1, and provide evidence for the specific CREDs-based driver of such an effect (second-order beliefs) in Experiments 1 and 2. Finally, a third experiment demonstrates the generalizability of the effect to other public goods that are even more highly non-normative than residential solar.

We begin with the field study, and examine the number of Solarize installations achieved in each town. As predicted, more people installed solar panels through Solarize in towns whose

ambassador also installed through Solarize, compared to towns whose ambassador did not install through Solarize (Figure 1; linear regression including controls for Solarize campaign type and timing, b=19.11, 95% CI [3.99, 34.22], p=.014). This result is robust to controlling for important characteristics of the towns and the ambassadors: the number of residential solar panel installations in the town before the Solarize campaign, the number of homes suitable for solar panel installation in the town, the gender of the ambassador, whether the ambassador served in an official town government role and whether the ambassador had already installed solar panels before the Solarize campaign (see Supplementary Information)

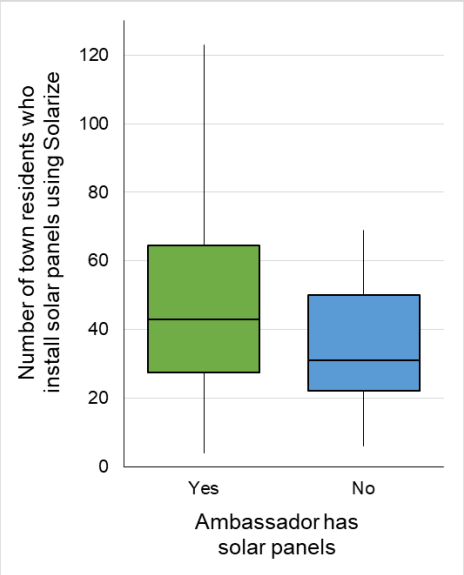

***Fig 1*. Ambassadors who install solar panels through Solarize are more successful at convincing others to participate in the program than ambassadors who do not.** *Shown are the number of people per town who installed solar panels using the Solarize program, as a function of whether that town's solar ambassador themselves installed using Solarize. Box-and-whiskers plot indicates the minimum, 25th percentile, 50th percentile (median), 75th percentile, and maximum values.*

To help support a causal interpretation of this correlational finding by addressing potential endogeneity concerns, we next perform an instrumental variable (IV) regression. IV regression is the standard technique in econometrics for obtaining causal estimates when there is concern that the main variable of interest is correlated with other unobserved factors that influence the outcome variable[30] (for details, see SI Section 6). For example, it may be that ambassadors who signed up during the program were more motivated in their role or that they were more knowledgeable about the program as a result of their having experienced the sign-up process. Or, it may be that installing solar was more attractive in towns with better Solarize installers, such that both ambassadors and other townspeople were more likely to install. To support the claim that the effect we observe is not attributable to these (or other) unobserved variables, we instrument for ambassadors' solar panel installations through the Solarize program with a variable for whether the ambassador's home was suitable for a solar installation (as determined, e.g. by an assessor who evaluates roof exposure to sunlight). Given that ambassadors could only install through Solarize if their house was suitable, suitability is a useful instrument. Indeed, a test of suitability demonstrates that it is not a weak instrument (F-ratio of 25.90) and it

significantly predicts whether the ambassador installed using Solarize (b=.60, 95% CI [.36, .84], p<.001). Moreover, we believe suitability is a valid instrument because it is highly unlikely that suitability is correlated with potential unobserved confounding variables, such as ambassador motivation or installer quality, because suitability is based on predetermined features of the ambassadors' roof structure and shading (for further discussion of validity, see SI Section 6). In our instrumented regression, we continue to find a significant positive effect of ambassador installation on the number of townsperson installations (b=27.10, 95% CI [9.69, 44.51], p=.002), supporting our causal interpretation.

Thus, the field study provides evidence in support of our CREDs-based hypothesis: ambassadors were more effective at convincing others to install solar panels using Solarize when they themselves engaged in that behavior, rather than just advocating it without the accompanying action.

To demonstrate causality experimentally, and to investigate the mechanisms driving this effect, we complement the field study with three pre-registered experiments using random assignment. These experiments recruit participants from the online labor market Amazon Mechanical Turk, which is substantially more demographically diverse than typical student samples[31-33]. Of particular relevance here, 52% of our participants indicated being past or current homeowners, and all of our results are robust to excluding participants without such experience (see SI Section 3).

Experiments 1 and 2 recreate the main contrast of the field study: subjects are presented with a description of the Solarize campaign, a description of a solar ambassador who we described as either choosing to install solar panels using Solarize or choosing not to, and an appeal from the solar ambassador detailing the benefits of the program. Subjects then indicate how likely they would be to install solar panels through the Solarize program. As in the field study, Experiment 1 (N=200) finds a significant effect of the ambassador installing using Solarize, such that subjects report a higher likelihood of installing using Solarize if the ambassador installed using Solarize (m=5.06, 95% CI [4.80, 5.32]) than not (m=3.97, 95% CI [3.66, 4.28], t(198)=5.31, d=.75, p<.001); see Figure 2a,b. Thus, Experiment 1 successfully replicates the findings of the field study using random assignment.

Experiment 1 also provides initial insight into the mechanism underlying this effect using a correlational mediation analysis. The key prediction of our CREDs-based theory is that second order beliefs drive the effect of ambassador installation on participants' willingness to install. Thus, we developed a 12-item second order beliefs scale (α=.96) in which participants indicate their agreement with a range of statements regarding the ambassador's beliefs about the benefits of the Solarize program (see SI Section 8.1.3 for details). As predicted, we find that our second-order beliefs scale significantly (and fully mediates) the effect of ambassador installation on participants' willingness to install (97% of effect mediated); see Figure 2c.

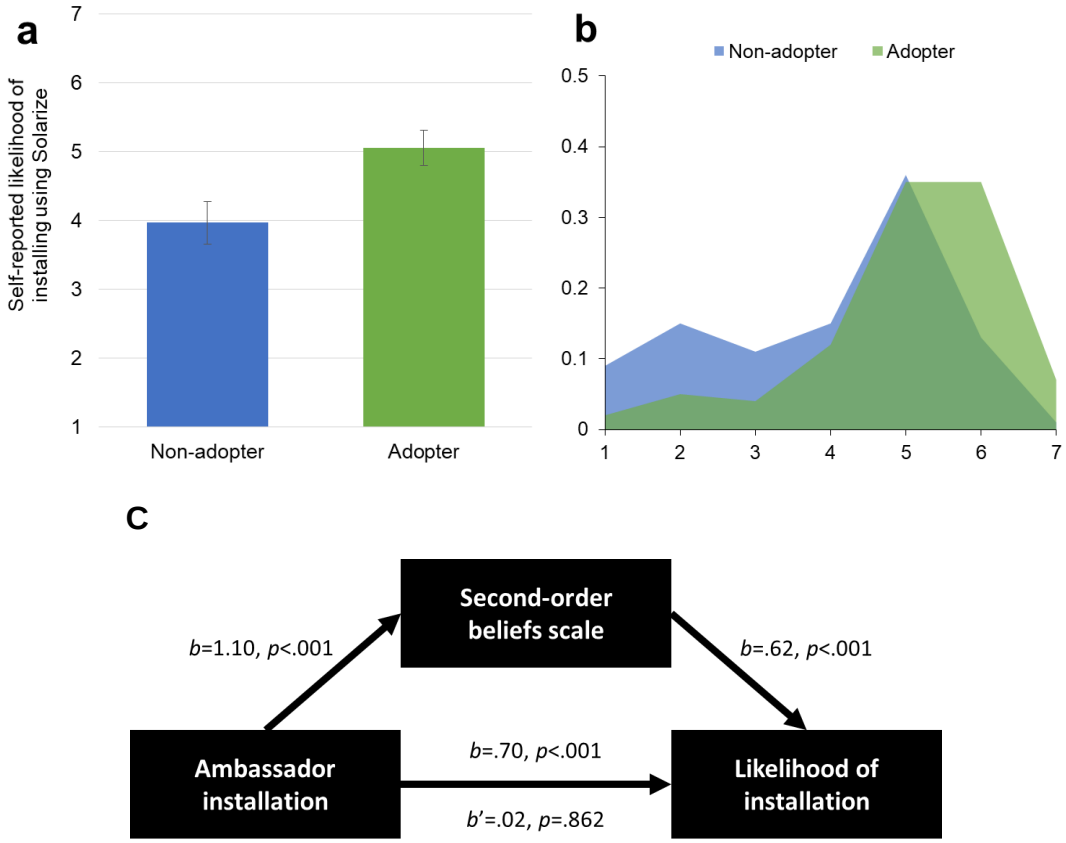

Fig 2. Ambassador installation influences participants' intentions to install through Solarize. *Shown are (A) means (with 95% CIs) and (B) distributions of solar panel installation intentions using Solarize (1-7 Likert scale), as a function of whether or not the ambassador was described as having installed solar panels using Solarize. (C) Participants' second order beliefs (i.e. their beliefs regarding the ambassador's beliefs regarding the benefits of Solarize) fully mediate the effect of ambassador installation on participants' installation intentions. Shown are the correlation between ambassador installation and second-order beliefs scale, the correlation between second-order beliefs scale and reported likelihood of Solarize installation, and the correlation between ambassador installation and self-reported likelihood of Solarize installation without (b) and with (b') the participant second order beliefs scale as a covariate.*

Experiment 2 (*N*=399) uses an *experimental* mediation design[34] to provide further support for the key role of second order beliefs in driving the effect of ambassador adoption, and to rule out two competing explanations. To do so, we use a 2x2 between-subjects design that crosses the manipulation of whether the ambassador installs using Solarize (from Experiment 1) with a direct *manipulation* of second-order beliefs regarding the benefits of residential solar. Specifically, participants are given direct information about the ambassador's beliefs regarding the benefits of residential solar (they are informed about accidentally overhearing the ambassador speaking in confidence and expressing either a positive or negative view of residential solar). Thus, in Experiment 2, participants do not need to rely on the ambassador's installation behavior when inferring what the ambassador truly believes – and thus, CREDs predicts that ambassador installation should have much less impact in Experiment 2 compared to Experiment 1. A two-way ANOVA finds a significant (and very large) main effect of second-

order beliefs, such that subjects report a higher likelihood of installing using Solarize when the ambassador expresses belief in the benefits of residential solar (m=5.20, 95% CI [5.01, 5.39]) compared to when the ambassador expresses a belief that residential solar is not beneficial (m=2.40, 95% CI [2.17, 2.63], F(1,395)=340.79, d=1.86, p<.001); as well as a significant (but quite small) main effect of the ambassador installing using Solarize, such that subjects report a higher likelihood of installing using Solarize if the ambassador installed using Solarize (m=4.00, 95% CI [3.71, 4.30]) than not (m=3.60, 95% CI [3.31, 3.88], F(1,395)=6.08, d=.25, p=.014); see Figure 3. (There was no significant interaction between ambassador installation and second-order beliefs (F(1,395)=2.48, p=.116). Critically, the effect of ambassador installation in Experiment 2 (d=.25) was much smaller than in Experiment 1 (d=.75), providing causal evidence that second order beliefs mediate 59% of the ambassador installation treatment effect (participants were randomly assigned simultaneously across Experiments 1 and 2 to enable this comparison). See SI Section 1.2 for details regarding this experimental mediation approach.

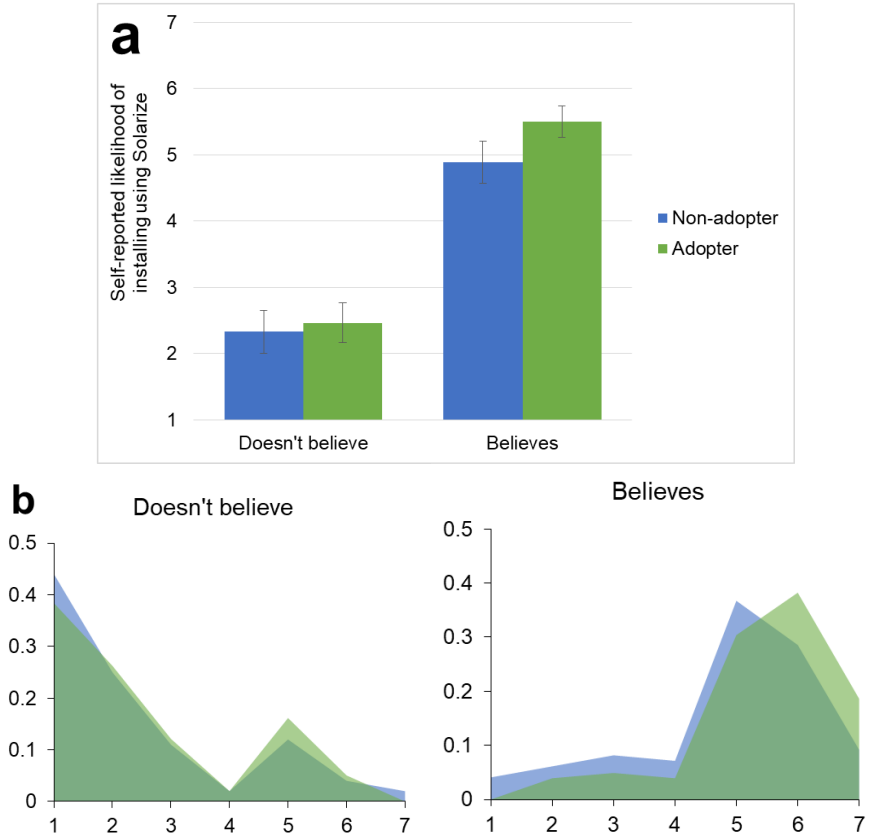

Fig 3. Second-order beliefs explain the effect of ambassador installation on participants' installation intentions. *A) Installation intentions solar panels using Solarize (1-7 Likert scale), as a function of whether the ambassador installed solar panels using Solarize, and whether the scenario indicated that the ambassador believed in the benefits of solar. Error bars represent 95% CI of the mean. B) Shown is the distribution of the data. We see that, in contrast to Experiment 1, when information about the ambassador's beliefs are directly provided in Experiment 2, there is little effect of whether the ambassador installed on participants' installation intentions.*

Experiment 2 also provides evidence against two alternative explanations of the ambassador installation effect. The first stems from the fact that the ambassador who advocates for installing solar, but does not install solar himself, is a hypocrite. Hypocrites are typically disliked and seen as immoral or untrustworthy[35,36]. Thus, it could be that participants make negative character judgments about the hypocritical ambassador, and for this reason ignore his recommendation regarding the Solarize program. If so, the correspondence between the ambassador's words and actions would be the driver of the effect, rather than second order beliefs. The second alternative explanation involves descriptive social norms[37]: it could be the ambassador installing solar panels shifts participants' impression of how many others are installers, and that this change in perceived descriptive normativity – rather than second order beliefs – is what influences participant installation intentions.

Both of these alternative explanations are ruled out, however, by the following observation from Experiment 2: participants' installation intentions are much higher when the ambassador chooses not to install (and therefore is hypocritical and projecting a norm of non-installation) but is overheard expressing a true belief in the benefits of solar (m=4.89, 95% CI [4.59, 5.19]), compared to when the ambassador does install (and is therefore *not* a hypocrite and is projecting a norm of installation), but is overheard to *not* truly believe in the benefits of solar (m=2.46, 95% CI [2.14, 2.79], $t(195)=10.83$, d=1.54, $p<.001$). Thus, when put in conflict, second-order beliefs override actions in their impact on installation intentions. This contrast further emphasizes the centrality of second-order beliefs, and is starkly inconsistent with the predictions of alternative accounts whereby dislike of the ambassador for his hypocrisy, or the impact of his actions on perceived descriptive normativity, explain the results of Experiment 1.

Finally, Experiment 3 (N=1206) demonstrates that the effect observed in the earlier experiments extends to public goods which are even more clearly non-normative than solar panel installation. Specifically, we replicated the design of Experiment 1 using four behaviors with our norming survey indicated were strongly non-normative from both a descriptive and injunctive perspective (see SI Section 2): wearing a face mask in public whenever one is sick with the flu or a cough; replacing grass lawns with more sustainable ground cover; buying carbon offsets for flights; and buying only used consumer goods. In a 4x2 between-subjects design, participants are presented with a description of a community-organization campaign promoting one of these four behaviors, a description of a community organizer (ambassador) who does or does not engage in the behavior in question, and an appeal from that ambassador detailing the benefits of the behavior. Participants then indicate how likely they would be to engage in the behavior, and lastly complete our second order beliefs scale (α=.91). See SI Section 1.2 for experimental details.

As per our pre-analysis plan, we treat each behavior as a 2-condition experiment and calculate the effect of the ambassador engaging versus not engaging in the behavior on participant intentions. We then perform a random-effects meta-analysis on the four effect sizes. The results reveal a significant positive effect of the ambassador engaging in the behavior (d=.33, 95% CI [.21, .44], Z=5.56, $p<.001$), and no evidence of heterogeneity in effect size across behaviors ($\chi^2(3)=3.08$, p=.379); see Figure 4. Finally, aggregating over the four behaviors we find that the second-order beliefs scale significantly and fully mediate the effect of community organizer contributions (89% of effect mediated; see SI Section 3.2). Thus, Experiment 3 shows that the

CREDs-based effect documented in the earlier studies can promote additional truly non-normative public goods.

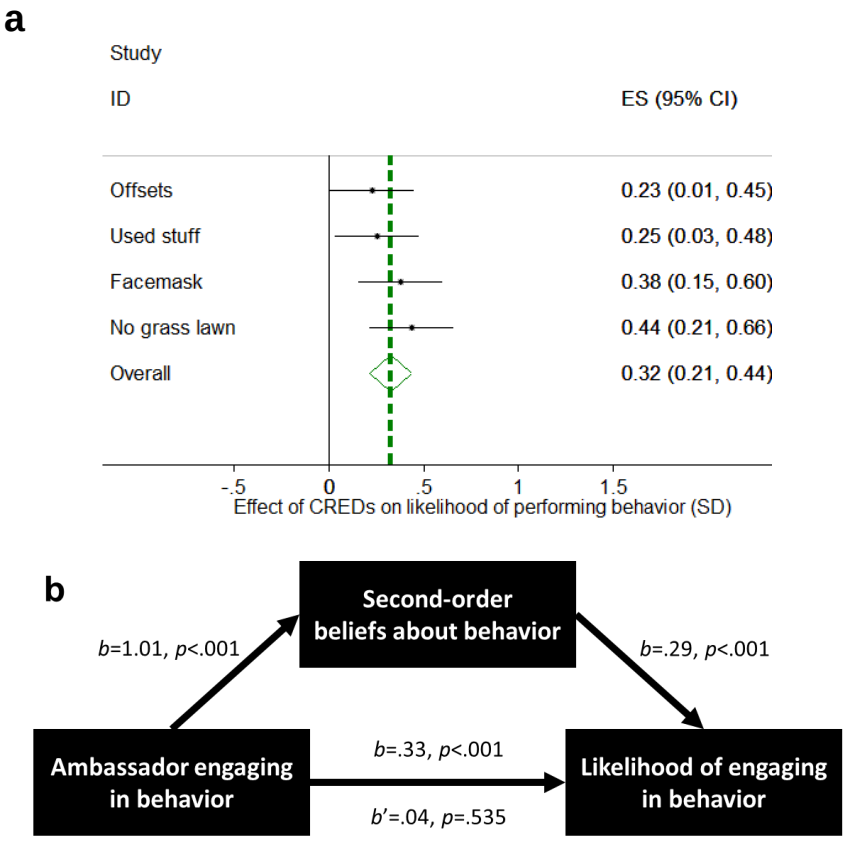

Fig 4. Ambassador engagement promotes adoption of highly non-normative public goods. *A) Random effects meta-analysis of the impact of the ambassador engaging in the behavior they are promoting on participants' intentions to engage in that behavior (1-7 Likert scale), across four highly non-normative public goods. Effect sizes (ESs) were measured as standardized regression coefficients on an indicator for the ambassador engaging in the behavior. Error bars indicate 95% confidence intervals (CIs). The relative sizes of the gray boxes indicate the weighting assigned to the studies by the meta-analysis. ANOVA produces equivalent results; see SI Section 3.3. B) Because there is no evidence of heterogeneity in the effect of CREDs across non-normative public good scenarios, we collapse across scenario and see that participant second order beliefs fully mediate the effect of ambassador engagement on participant engagement intentions. Shown is the correlation between ambassador engagement and the participant second-order beliefs scale, the correlation between participant's second-order beliefs and participant engagement intentions, and the correlation between ambassador engagement and participant engagement intentions without (b) and with (b') including the participant second order belief scale as a covariate.*

The results presented here demonstrate the power of credibility enhancing displays (CREDs) for motivating real-world contributions to non-normative public goods in a large field study and three online experiments. Specifically, community organizers (ambassadors) advocating a

program for residential solar panel adoption are more successful when they have installed residential solar through the program themselves; this effect is driven by perceptions about the ambassadors' belief in the benefits of the program; and the effect extends to public goods-promoting behaviors which are strongly non-normative from both a descriptive and injunctive perspective.

Our work is of substantial importance for theories of cultural evolution, in which CREDs play a major role. We are aware of only one published study providing empirical support for CREDs, specifically in the context of religiosity, showing that people who report more exposure to their caregivers' CREDs for religiosity report higher theism[20]. There is also a related human developmental literature showing that children learn from models' actions rather than their words[38,39]. While it has been theorized that CREDs may help explain prosocial behavior more broadly[40], we believe the present study is the first to provide empirical evidence for this claim. Further, our experiments provides specific support for the key role of second-order beliefs—the central concept in CREDs theory—in this effect.

Even more importantly, we are the first to apply the logic of CREDs to the spread of *non-normative* public goods, demonstrating an important new role for this theory in solving one of the major outstanding challenges in cooperation research. While numerous mechanisms exist for enforcing widely held norms[6], much less is known about how to spread rare, currently unpopular, or entirely new/innovative prosocial norms. Our field study demonstrates the ecological validity of our conclusions regarding CREDs as such a mechanism.

The present work also contributes to the literature on promoting public goods contributions in the field[9] by demonstrating the efficacy of bottom-up approaches, as well as non-monetary approaches. Finally, it contributes to the practical literature on the diffusion of solar panel adoption[25,41,42], demonstrating the efficacy of recruiting organizers who themselves plan to adopt residential solar. While this result might seem obvious in retrospect, the data suggest that it was not in fact self-evident in prospect: only 34% of solar ambassadors recruited as Solarize CT community organizers were people who themselves installed residential solar through the program.

Our world is becoming increasingly globalized—connecting individuals and groups of diverse backgrounds—and increasingly technological—adding complexity and opacity to the causal effect of our behaviors on our physical and social environments. Problems of cooperation and the provision public goods are therefore becoming ever more important and urgent. Whether advocating for residential solar panels or public transportation, supporting local businesses or civil liberties, progress is possible, but our campaigns will be more effective if they are built on a foundation not of words, but of action.

Data Availability Statement. All data are publicly available at: http://osf.io/wbmjc.

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