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Enhanced “Green Nudging”: Tapping the Channels of Cultural Transmission

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Abstract

This paper relates channels of cultural transmission to “green nudging”. It studies the effectiveness of this behavioral policy measure as to the promotion of sustainable consumption. The impact of “green nudges” is constrained for it is subject to decay and temporary behavioral adjustments. We argue that “enhanced green nudges” incorporating social learning biases that are based on humans’ evolved capacity for culture are more likely to entail persistent behavioral changes due to the inducement of preference learning. We consider biases based on norm psychology, conformity, self-similarity, and the influence of role models. Moreover, these biases’ effectiveness in cultural transmission hinges on whether the learning environment resembles the one in which they evolved during human phylogeny. Hence, “enhanced green nudges” are instruments to lastingly introduce environmentally begin consumption patterns. Several scenarios based on a model of cultural evolution illustrate our arguments.

Keywords

Nudging, Cultural evolution theory, Consumption, Social learning, Sustainability

JEL Classifications

A12; B52; D00; Q01

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1. Introduction

This article studies the behavioral effectiveness of “green nudging”. The latter represents an important policy measure to promote sustainable consumption among consumers (e.g., van den Bergh et al. 2000; Sunstein & Reisch 2013; Schubert 2017). Evidence shows, however, that the impact of “green nudges” on agents’ behavior is reflected by rather short-lived behavioral adjustments subject to decay (e.g., House of Lords 2011; Ayres et al. 2013; Allcott & Rogers 2014; Momsen & Stoerk 2014). In this context, we claim that “enhanced green nudges”, which incorporate cognitive biases in social learning originating from humans’ evolved capacity for culture, can induce the acquisition of enduring “green” preferences. A prerequisite for this behavioral effect to enfold is that learning environments resemble the ones in which biases evolved in humans’ phylogenetic past. “Enhanced green nudging” taps the channels of cultural transmission via which agents socially acquire their preferences. Several biases in social learning are considered, such as norm-following behavior, conformity, self-similarity, and the influence of role models. We expose the deep evolutionary origins of these learning dispositions by drawing on insights from cultural evolution theory (see Boyd & Richerson 1985; Laland 2004; Henrich 2016; Cordes 2019). These features of social learning can serve as powerful political instruments to induce enduring shifts toward more environmentally begin behaviors. We also show that default-based “nudges” can induce the acquisition of preferences via specific, non-social cognitive biases.

Experimental findings from psychology on cognitive biases in individuals’ information acquisition led to the emergence of the research fields “behavioral economics” (see, as a point of origin, Kahneman & Tversky 1972) and, more specific, “behavioral environmental economics” (e.g., Croson & Treich 2014). Biases in social learning have also been scrutinized in anthropology (see Richerson & Boyd 2005). Insights from these fields have been used to modify agents’ choice architectures to direct, or “nudge”, decisions toward ecologically more sustainable behavior (e.g., van den Bergh et al. 2000; Buenstorf & Cordes 2008; Gowdy 2008; Thaler & Sunstein 2008; Gual & Norgaard 2010; Abrahamse & Steg 2013; Schubert 2017). These approaches differ from established views on economic behavior as to their assumptions on agents’ cognitive constraints and the – biased – acquisition of information for decision-making and preference formation (also Gigerenzer 2008).

Humans routinely face situations in which they have to deal with strong limitations on their cognitive capacities as to the processing of information, especially in complex cultural environments. Confronted with these settings in its evolutionary past, the human brain evolved a set of cognitive biases that guide social learning (see Richerson & Boyd 2005; Henrich 2016; Brewer et al. 2017). In our analysis, we account for a role model bias, a conformity bias, a self-similarity bias, and biased learning due to norm psychology. Cultural evolution theory explains the anthropological origins of these learning biases: once cultural adaptation became the cornerstone of humans' tremendous ecological success about two million years ago, the main selection pressure on genes led to improving the psychological skills to acquire, store, process, and organize the knowledge increasingly available in individuals' cultural environments (see Chudek & Henrich 2010; Mesoudi 2016). Enhanced cultural learning abilities gave rise to close interaction between an accumulating body of cultural knowledge and genetic evolution. This coevolutionary process between genes and culture drove the emergence of specialized cognitive abilities including powerful social learning biases that guide the tapping of cultural knowledge (see Henrich 2016). It created features of modern humans' psyche relevant in explaining contemporary behavior and its changes.

The channels of cultural transmission opened up by these biases also determine a great share of an individual's set of preferences: these are fundamentally shaped by cultural environments and social learning therein (see Bowles 1998; Cordes 2019).[1] Hence, human preferences are neither fixed nor homogenous, but malleable (e.g., Sen 1977; Elster 1982; Bisin & Verdier 2000; Schubert 2012). Agents individually and socially learn new ones or modify existing ones (see Schubert & Cordes 2013; Hoff & Stiglitz 2016; Baumgartner et al. 2022).[2] We suggest that evolved cognitive biases taking effect in cultural transmission can be harnessed by "enhanced green nudges" to profoundly shift agents' preferences toward environmentally begin ones. When operating in environments similar to those they evolved in, these social learning forces are strong drivers of behavioral adaptation and preference change (e.g., McElreath et al. 2003; Laland 2004). "Nudges" not drawing on these features of evolved cognitive learning biases do not entail similarly extensive and persistent changes in behavior.

To organize our argument, we consider several cognitive biases in a model of cultural evolution (Boyd & Richerson 1985; McElreath & Henrich 2007; Mesoudi 2016). It illustrates their influence in individual and social learning that both underlie preference acquisition and corresponding consumption. Our approach helps to differentiate the long-term effectiveness of "green nudges" vis-à-vis "enhanced green nudges" as well as some features of their interplay. Moreover, we assume the strength of evolved cognitive biases to vary with the learning environment's characteristics. We discriminate the dissemination of a "green" preference from the level of overt "green" behavior in a population. Moreover, the model captures fading processes as to the behavioral effects of "nudges" absent profound preference learning. Finally, it depicts an "inducement

[1] Humans also acquire preferences for maladaptive behaviors that are against their "best interests" via social learning, e.g., when status-oriented social comparison leads to overconsumption (Schubert & Cordes, 2013).
[2] This observation represents a central challenge for traditional economic theory whose utility maximization procedure relies on given sets of stable preferences as fixed "measuring rods".

effect” in preference acquisition caused by default-based “nudges”. Several scenarios based on different parameter constellations of the model are presented.

The paper is organized as follows. Section 2 discusses the role of “nudges” in attempts to influence agents’ consumption choices and elaborates on the advantages of “enhanced green nudges”. Next, Section 3 introduces a formal model of cultural evolution. Based on this model, Section 4 presents several scenarios of preference acquisition via channels of cultural transmission. These scenarios demonstrate the effectiveness of different forms of “nudging” in altering consumption behavior in different learning environments. They allow the derivation of some propositions and show implications for environmental policy making. Section 5 concludes.

2. From “Green Nudges” to “Enhanced Green Nudges”

“Nudges” are established instruments in environmental policy that exploit cognitive biases taking effect within certain choice architectures. They are defined as attempts to influence the choice of an agent in a predictable way, for example, by presenting a decision problem in a certain manner, without changing monetary incentives or the option set itself (see Thaler & Sunstein 2008; Croson & Treich 2014; Schubert 2017). For instance, Pichert and Katsikopoulos (2008) show how a default alters energy consumption: citizens of Schönau in Germany, conservative voters by majority, stayed with the default option “green energy” set by the local utility even though opting-out was easy, the option opposed their political attitudes, and was more expensive (also Sunstein & Reisch 2013). A “status quo bias” that combines “loss aversion” and “endowment effects” explains this behavior (Kahneman et al. 1991). These “soft” interventions into decision-making are legitimated by societal goals, for example, the transition toward environmentally sustainable modes of consumption (van den Bergh et al. 2000; Momsen & Stoerk 2014; Grilli & Curtis 2021). “Nudges” have several advantages over traditional regulation: they are cost effective as compared to laws or marketing campaigns, are easy to implement, and are often widely accepted by the population (Schubert 2017). The most frequent critique of “nudges” addresses their paternalistic and manipulative character. Thaler and Sunstein (2003), therefore, recommend a high level of transparency when introducing “nudges” and suggest a “libertarian paternalism” that, while modifying choice architectures, respects individuals’ general freedom of choice.

An important question is whether “green nudges” promote long-run behavioral change or merely trigger short-term adjustments. In fact, most of them are rather limited as to long-term effects on agents’ behaviors (e.g., House of Lords 2011; Ferraro et al. 2011; Buckley 2020; Grilli & Curtis 2021). Momsen and Stoerk (2014) show that “nudges” including priming, mental accounting, framing, and decoy proved ineffective. Also mentioning social norms – without visibility of behavior or direct communication among agents – failed to lastingly induce pro-environmental behavior. The only "nudge" whose behavioral effect last longer was a default-based "nudge" (also Croson & Treich 2014).[3] Allcott and Rogers (2014) observe that consumers' energy saving efforts triggered by a "nudge" invoking home energy reports including abstract social comparisons decay relatively quickly after "nudging" stops (also Ayres et al. 2013). Evidence reviewed by Abrahamse and Steg (2013) suggests that in before-after settings the "nudge"-based treatment effect dissipates when the measure is no longer in place. The initial effect only becomes more persistent (albeit at low levels) if the intervention continues over longer periods of time. Consequently, a severe shortcoming concerns the long-term effect of "green nudges": they exhibit behavioral effects subject to fading processes.

As humans are cultural beings, preferences are continuously formed by powerful social learning forces throughout an individual's life (e.g., Hoff & Stiglitz 2016). This malleability of preferences provides the basis for persistent changes in behavior. "Enhanced green nudges" acting in certain learning environments have the potential to induce such lasting preference shifts, since they incorporate channels of (biased) cultural transmission relying on humans' evolved learning capacities (Henrich 2016; Mesoudi & Thornton 2018). Within the scope of our analysis, we focus on the following biases in cultural transmission that may be integrated into "enhanced green nudges":

(1) Social learning features direct biases (see Richerson & Boyd 2005; McElreath & Henrich 2007). Due to evolved cognitive dispositions that increase the inherent attractiveness of particular cultural traits, directly-biased people preferentially adopt these traits based on their contents rather than others (see Sperber 1990; Boyer 1999; Henrich 2016). A case in point are deeply-rooted concerns about status and an individual's relative social position within a peer group. This bias in perception translates into strong social comparison forces and a preference for status-signaling or positional goods or behaviors (e.g., Veblen 1899; Ng 2003; Frank 2008). Most status-related consumption acts are rather resource-intensive. However, also environmentally begin consumption behaviors may serve as status-signaling means in certain communities.

(2) Another evolved bias taking effect in cultural transmission is conformity. It represents a heuristic to figure out well-adapted kinds of behavior by drawing on the frequency with which they are shown by agents in a particular cultural context (e.g., Aronson et al. 2002; Kameda & Diasuke 2002; Cialdini & Goldstein 2004; Corriveau & Harris 2010). Agents are more likely to pick the behavioral variant that is modeled by the majority of group members, i.e., they discriminate against behaviors that are rare among peers. Conformity explains many aspects of group behavior including nonlinear behavioral changes, such as threshold and critical mass phenomena (e.g., Cordes et al.

[3] Below, we will introduce an "inducement effect" in preference acquisition based on a default that accounts for this relative higher effectiveness.

2010). Once a "green" behavior is displayed by the majority in a peer group, this bias fosters its spreading. On the other hand, it may also favor environmentally harmful behaviors prevalent in a population. In that case, other instruments have to be applied to lead the population out of this "lock-in" (see Buenstorf & Cordes 2008).

(3) Moreover, norm psychology as a cognitive disposition to comply with a group's rules plays an important role in biased social learning. It is another feature of human cognition evolved by means of gene-culture coevolution (see Henrich & McElreath 2003; Chudek & Henrich 2010; Henrich 2016). This disposition has been caused at the genetic level by the enforcement of social norms in group culture contexts. Phenotypes endowed with a propensity to obey norms enjoyed a relative advantage in these settings. Moreover, this psychological disposition was of great adaptive value for it enabled the stabilization and maintenance of cooperation and other prosocial norms at the group level (Soltis et al. 1995).[4] Norm-following behavior supports environmentally begin behavior once it is established as a norm in a reference group, for example, via a prestigious role model (Schultz et al. 2007). Labels on environmentally friendly products not only provide additional information to buyers, they also allow consumers to reveal their norm-following lifestyle to the reference group (Teisl et al. 2008; Bratt et al. 2011).

(4) Finally, a particularly strong force in cultural transmission is the role-model bias. Evidence from psychology and anthropology shows that the adoption of behavioral traits is frequently conditioned by observable attributes of individuals exhibiting the trait (e.g., Rogers 1983; Harrington Jr 1999; Labov 2001; Atkisson et al. 2012). Individuals who are perceived as models are characterized by attributes such as success, general competence, status, or prestige. Copying behaviors of role models represents a simple evolved heuristic that enables social learners to identify behavioral traits well-adapted to complex environments (Henrich & Broesch 2011; Henrich 2016). A model-based bias results if social learners use the value of a second trait that characterizes a model (e.g., prestige) to determine the attractiveness of that individual as a model for the primary trait (e.g., consumption behavior). Hence, the role model bias is an indirect one. It is even more effective if a model is similar to the target individual along certain dimensions of self-similarity, such as sex, dialect, ethnicity, regional provenance, socio-demographics, or other measures of proximity (e.g., Shutts et al. 2009; Farrow et al. 2017).

Since all these social learning biases are endowed with evolutionary roots in human phylogeny, they strongly influence cognition and determine which information from an individual's complex cultural settings will be subject to deliberate processing. These cognitive dispositions crucially affect the constitution of an agent's set of preferences that is, to a great extent, determined by her cultural environment. Incorporating social learning biases into "enhanced green nudges" turns these into

[4] However, due to this cognitive disposition, cultural evolution can also produce social norms that tend to be stable even if they neither serve the group nor the individual.

powerful instruments in lastingly changing consumers' preferences – a prerequisite for a transition toward "green" behaviors beyond mere temporary behavioral adaptations. However, a requirement for this behavioral impact to be fully realized is that social learning takes place in "natural" settings including, for example, direct observation of models, face-to-face communication with peers in small group-contexts, or – with a lower effect – the presentation of norms via the media. We claim that the effectiveness of "enhanced green nudges" in cultural transmission hinges on whether the learning environment resembles the one biases originated from in our evolutionary past.

3. A Model of "Green" Preference Acquisition

Our model of cultural evolution captures biased individual and social learning underlying the acquisition of preferences toward one out of two behaviors, A and B. Let a represent the preference for the "green" behavior, A. b denotes the one for the environmentally more harmful behavior, B. Agents' preferences represent a positive attitude toward the respective behavior and a willingness to adopt it. The state of the population of N individuals is given by the frequency of agents that prefer A, i.e., those holding preference a, labeled p $(0 \leq p \leq 1)$. The share of preference b is given by $1 - p$. G measures the share of overt "green" behavior in the population $(0 \leq G \leq 1)$, i.e., the observable demand for A. As shown, the frequency of A among agents does not necessarily correspond with the grade of dissemination of the preference for it. A "green nudge" may introduce pro-environmental behavior to a population without changing people's preferences. In that case, some of the observed "green" behavior originates from mere (short-term) behavioral adjustment. p is assumed to be small in the beginning, while the value of G is determined by the political application of "green nudges". We define recursion equations in discrete time that predict the frequencies of p and G in the next stage of preference learning and "nudging", p' and G', given their current frequencies (Cavalli-Sforza & Feldman 1981; Boyd & Richerson 1985). We focus on (1) the fading of "green nudges", (2) the inducement of environmentally begin preferences via default-based "nudging", (3) a direct bias in individual learning, and (4) cultural evolutionary forces that bias preference acquisition via social learning: a role model and a conformity bias that also include aspects of self-similarity and norm-following. (5) Finally, a dynamic system integrates these forces in preference acquisition.

3.1. Fading phenomena in "green nudging"

Evidence shows that most "green nudges" are subject to decay: observable "green" behavior introduced to a population by this instrument decreases in time if agents do not acquire a stable preference for the environmentally begin option. Equation (1) describes this fading process: a partial recursion determines G in the next time step, G', given the value of G in this period and a fraction $\mu G(G-p)$ of agents that switches from the “green” variant, A, to the conventional choice, B, representing the fading process:

$$G' = G - \mu G(G-p). \qquad (1)$$

The equilibrium frequency of overt “green” behavior, $\hat{G}$, is calculated by subtracting G from both sides of (1) $(G' - G = 0)$ and yields $\hat{G} = p$ and $\hat{G} = 0$. If, after “green nudging” has been applied as a political instrument, $G > p$ in the population, a fraction of the observed overt “green” behavior is not accompanied by a corresponding acquisition of a preference for the environmentally begin variant. It is merely temporarily induced by the “nudge”. As a result, G decreases until $G = p$, i.e., we see a continuous decay of the “nudging” effect. The pace of fading hinges on the parameter μ that scales its strength. On the other hand, as long as $p > G$ due to prior preference acquisition, the share of “green” behavior among agents, A, increases until the equilibrium at $\hat{G} = p$ is reached. Holding a “green” preference, a, sooner or later translates into overt “green” behavior.[5]

3.2. The inducement of preferences via default-based “green nudges”

Despite the fact that also the effect of default-based “green nudging” on agents’ choice behavior is subject to constant decay (e.g., Allcott & Rogers 2014), this specific instrument nevertheless may induce lasting shifts in the preferences of some agents. Determining a preset option potentially affects preference acquisition via particular cognitive channels: the “endowment effect” and “loss aversion” (see Kahneman et al. 1991). Agents value the preset option relatively higher because it is regarded as being integral part of an individual’s endowment and thus serves as a reference point. Opting out of the default then implies a loss. Pichert and Katsikopoulos (2008) show that consumers asked for more money to give up “green” electricity than they were willing to pay for it. Hence, a preset option affects preference learning. This “inducement effect” is captured by another partial recursion that depicts the acquisition of a by a share of consumers by means of “default-based green nudging”:

$$p' = p + \delta G(1-p). \qquad (2)$$

In every time step, some consumers that have been subject to “green default-nudging” (with the default set to A), measured by G, and that have not yet acquired preference a, captured by $(1-p)$, lastingly adopt the “green” preference due to the cognitive biases

[5] For $G \neq 0$, i.e., at least one individual exhibiting A is required to trigger an increase of G.

mentioned above. δ measures the strength of this preference inducement effect by determining the share of $G(1-p)$ that translates into p in the next stage.

3.3. Directly biased preference learning

We extend Equation (2) with an expression for a direct bias that depicts individual, hedonistic learning in consumption (Boyd & Richerson 1985; Buenstorf & Cordes 2008). In the transition to more sustainable behaviors, agents' frequently experience the conflict of cost, practicability, or convenience motives with "green" choices. While being more harmful to the environment, conventional commodities or services are often hedonistically more attractive in terms of various non-environmental characteristics: they may entail cost advantages, have offered more prior experiences, provide more rewarding sensory pleasures due to perfected performance, have a better supporting infrastructure, or are technologically more mature (see Cordes & Schwesinger 2014). In our context, this conflict translates into a direct bias favoring the acquisition of preference b. Therefore, "green" preferences may spread less or even be crowded out by the conventional variant. To capture the superiority of commodity B in individual learning, we assume that each preference a holder, given by p, has a certain chance of learning to favor the hedonistically more attractive alternative B, measured by γ_{ab}, in each time step. Accordingly, the partial recursion in Equation (2) modifies to

$$p' = p + \delta G(1-p) - p\gamma_{ab}. \quad (3)$$

Consumers encounter the alternative commodities or services. Based on their experience, a fraction γ_{ab} of agents acquires preference b and is subtracted in the recursion. Individual learning may also favor the environmentally begin variant: a status-based direct bias signaling "green" credentials to others would foster the dissemination of preference a in the population (e.g., Griskevicius et al. 2010).

3.4. The acquisition of "green" preferences via social learning forces[6]

The acquisition of persistent preferences for environmentally benign consumption choices is subject to the consciously controlled processing of relevant information, whose provision in turn strongly relies on social learning (e.g., Welsch & Kühling 2009; Cordes & Schwesinger 2014). As argued, cultural transmission is biased: adopters tend to socially acquire some cultural traits – in our case preferences for commodities or services – rather than others. To understand how cognition directs social learning, we account for

[6] This part of the model draws on Cordes and Schwesinger (2014).

several evolved cognitive biases: (1) the relevance of models in an agent’s social context differs. Peer consumers in different roles, proximity, and diverse personal characteristics, the family, activist groups, science, experts, or the media all vary in their credibility and influence. Hence, we assign different weights in cultural transmission to these entities, α_i ($\sum_i \alpha_i = 1$). We assume two models, M2 and M3, to represent close peers whose influence in social learning is high due to direct, personal communication with the individual (self-similarity bias). They represent a “natural”, group-bound learning environment akin to those biases evolved in. “Live models” M2 and M3 may show either preference, a or b, and may have varying weights (α_2 and α_3). Less weight in cultural transmission is given to a dedicated “green” model M1 (α_1) that always shows preference a. It proxies the influence of more “abstract” models acting through “symbolic modeling” in the media or via publications on sustainability issues. (2) To incorporate (normative) conformity into social learning, we look at sets of three models, whose frequency-dependent impact is expressed by a conformity bias parameter η. We assume that $0 \leq \eta \leq 1$, which implies that the weight of the more common preference in the set of models is increased. If $\eta = 0$, no conformity bias is present, while $\eta = 1$ maximizes its influence. The cultural transmission table showing the probability of agents adopting preference a or b given a particular set of social role models with different weights yields:

Table 1 Probability of acquiring preference a or b given a particular set of models (M1, M2, M3) with different weights (α_1, α_2, α_3) and frequency-dependent transmission (η).

Preference of			Probability That Agent Acquires Preference	
M1	M2	M3	a	b
a	a	a	1	0
a	a	b	$(\alpha_1 + \alpha_2) + \eta(1 - \alpha_1 - \alpha_2)$	$\alpha_3(1 - \eta)$
a	b	a	$(\alpha_1 + \alpha_3) + \eta(1 - \alpha_1 - \alpha_3)$	$\alpha_2(1 - \eta)$
a	b	b	$\alpha_1(1 - \eta)$	$(\alpha_2 + \alpha_3) + \eta(1 - \alpha_2 - \alpha_3)$

From this table, the frequency of a after social learning, p'', given that it was p' before, is

$$p'' = p'^2 + p'(1 - p')\{(\alpha_1 + \alpha_2) + \eta(1 - \alpha_1 - \alpha_2) + (\alpha_1 + \alpha_3) + \eta(1 - \alpha_1 - \alpha_3)\} + (1 - p')^2\{\alpha_1(1 - \eta)\}$$

$$= p' - (p' - 1)\big(\alpha_1 + \eta(p' - \alpha_1)\big), \tag{4}$$

which constitutes the partial recursion for the social learning phase including cognitive biases. It computes the frequency of each set of models, multiplies this by the probability that a particular set results in an individual acquiring preference a, and then sums over all possible sets of models. M1 shows the green preference a with probability 1. Conformity parameter η favors the more common preference within the set of models. The complete recursion for p, obtained by substituting the partial recursions for the inducement of preferences via default-based “green nudging” (2) and individual learning (3) into the recursion for biased social learning (4), is expressed as

$$p'' = (p + \delta G(1-p) - p\gamma_{ab}) - \big((p + \delta G(1-p) - p\gamma_{ab}) - 1\big)\Big(\alpha_1 + \eta\big((p + \delta G(1-p) - p\gamma_{ab}) - \alpha_1\big)\Big). \quad (5)$$

3.5. A two-dimensional dynamic system for the acquisition of preferences

We yield two coupled recursions, one describing the development of the frequency of the “green” preference, a, in the population, denoted by p, (6) and another one for G (7), the overt “green” behavior among consumers ($\Phi = \delta G(1-p) - p\gamma_{ab}$):

$$\Delta p = (p + \Phi) - \big((p + \Phi) - 1\big)\Big(\alpha_1 + \eta\big((p + \Phi) - \alpha_1\big)\Big) - p \qquad (p'' - p = \Delta p) \quad (6)$$

$$\Delta G = -\mu G(G - p) \qquad (G' - G = \Delta G). \quad (7)$$

4. “Green Nudges” and Preferences: Some Scenarios

In this section, several scenarios show that our model of cultural evolution delivers concrete propositions as to the effects of “green nudges”. Iterating the dynamic system for many individual and social learning as well as fading and preference inducement steps, we study its long-run properties and driving forces. The scenarios compare constellations of model parameters and the resulting developmental paths for its key variables, the frequencies of the “green” preference, a, and the overt “green” behavior, G, among consumers. Policy recommendations flow directly from this analysis.

4.1. The decay of the behavioral effects of “green nudges”

As argued, environmentally begin behavior introduced to the population by a “green nudge” is subject to decay. Most shifts in behavior triggered by these interventions exhibit a – at best – one-off effect as to behavioral adaptation. As long as there is no change in underlying preferences, no motivation exists that permanently induces “green” choice. Figure 1 shows a stylized version of this process: the share of overt “green” behavior, G, is decreasing continuously in time, i.e., *ceteris paribus*, we observe a fading process after an initially high “post-nudge” level of pro-environmental behavior. The strength of the decay process is $\mu = .2$, which is supported by empirical evidence (see Allcott & Rogers 2014). G declines until the equilibrium at $\hat{G} = p$ is reached.[7] The share of preference a, p, represents the baseline of G. These agents adopt, sooner or later, the environmentally begin behavior A. Initial values for p are low ($p_{start} = .1$). We suggest the following proposition:

Proposition 1: *Overt environmentally begin behavior introduced to a population by a “green nudge” not accompanied by corresponding preference learning, is subject to decay. This impairs the long-term effectiveness of “green nudges”.*

4.2. “Enhanced green nudges” and learning environments

A central feature of “natural” learning environments cognitive biases evolved from are face-to-face interactions with peers in small-group contexts (see Richerson & Boyd 2001; Henrich 2016). Moreover, role models, which constitute an essential component of such an environment, heighten the saliency of certain behaviors by drawing on prestige assigned by local peers (Henrich & Gil-White 2001; Atkisson et al. 2012). Direct communication of this kind is an effective channel of cultural transmission to disseminate norms, beliefs, or knowledge and to provide the information for individuals’ deliberate change of preferences. Accordingly, direct social interaction has been shown empirically to be superior in spreading environmental knowledge and behavioral change: a review study by Abrahamse and Steg (2013) concludes that face-to-face interaction is more effective in changing behavior than abstract feedback provision on the behavior of other community members (also Farrow et al. 2017). Young et al. (2017) find that social media cannot replicate the influence of face-to-face interactions. In the case of “green” electricity, personal communication with peers has been shown to be a crucial input to the deliberate adoption of corresponding “green” preferences (see Pahl-Wostl et al. 2008; Woersdorfer & Kaus 2011). Similarly, an empirical study by Welsch and Kühling (2009) suggests that direct communication in a community increases agents’ probability to subscribe to “green” electricity programs. They also attest a group-bound self-similarity bias: peers that are similar to the target individual along certain dimensions, such as income, demographics, or educational background, are relatively more influential in inducing behavioral change. Moreover, while being less powerful than direct communication, the media – and role models appearing therein – still can pave the

[7] With $\alpha_1 = 0$, $\alpha_2 = \alpha_3 = .5$, and $\eta = 0$, social learning has no effect on the frequency of a.

ground for and foster the diffusion of behavior introduced to a group by more immediate means of communication (see scenario below).

Visibility, saliency, and assignability of the behaviors of role models or peers represent further important aspects of settings that resemble ancient cultural environments. For a role model or conformity bias to take effect in group-bound cultural transmission, a model’s or peer’s behavior must be visible and assignable. In the case of a role model, exhibited behavior must also be related to her success, prestige, or status. Accordingly, Babutsidze and Chai (2018) find that peer behavior positively correlates with the adoption of visible climate change mitigation practices, but not with the adoption of non-visible mitigation behaviors. In a study by Welsch and Kühling (2009), people were more likely to install residential solar energy equipment if reference persons – neighbors, friends, or relatives – display this kind of consumption behavior. Further studies show that “block leaders” belonging to an individual’s social network provide a large effect on pro-environmental actions as to, for example, recycling or conservation, by exhibiting the corresponding behaviors (Grilli & Curtis 2021). In contrast, promoting sustainable electricity consumption is difficult due to its non-visibility, both for the consumer herself and an observer (see Fischer 2008; Grønhøj & Thøgersen 2011; Hargreaves et al. 2010). Reductions in electricity consumption or building energy performance standards will, therefore, not easily become a status-signaling lifestyle-choice by peers and role models. In contrast, the possession of solar systems is visible and therefore suited to function as status-signaling items in social comparison. Allcott and Rogers (2014) report the use of home energy reports to make electricity consumption more visible and comparable by providing feedback on own consumption and comparisons with self-similar peer consumers. This abstract learning environment involving anonymous peers, however, only induced modest reductions in electricity consumption (also Abrahamse & Steg 2013; Ayres et al. 2013) Furthermore, irrespective of the initial changes in overt “green” behavior, the subsequent decay of the “nudging” effect was significant. Agents did not acquire a preference for energy-saving behavior. In rather artificial learning environments, forces of cultural transmission predicated on evolved cognitive biases turn out to be less effective in lastingly changing behavior.

A scenario demonstrates the effect of an “enhanced green nudge” including role models on the diffusion of “green” preferences in a group of agents vis-à-vis a transitory change in behavior initiated by a conventional “green nudge” as described in Figure 1. The set of role models is constituted as follows: M2 and M3 are local peers whose high influence in cultural transmission emanates from direct interaction with the target individual and immediate visibility of their behaviors ($\alpha_2 = \alpha_3 = .45$). They represent a random draw from the peer group and mimic real face-to-face communication. Thus, M2 and M3 proxy for a “natural” learning environment with frequent encounters with self-similar models. Evolved biases are expected to be strong in such a setting. Moreover, M2 and M3 are characterized by changing frequencies of preferences a or b. We also introduce an exclusively “green” model M1, whose weight in cultural transmission is

$\alpha_1 = .1$. This model represents members of state and non-state institutions, non-local experts, or agents appearing on the media, such as politicians or scientists that are dedicated to promote “green” behavior. Since such role models are characterized by greater spatial, cognitive, or cultural distance to the target individual, M1 captures more abstract learning channels with a relatively lower weight in cultural transmission.

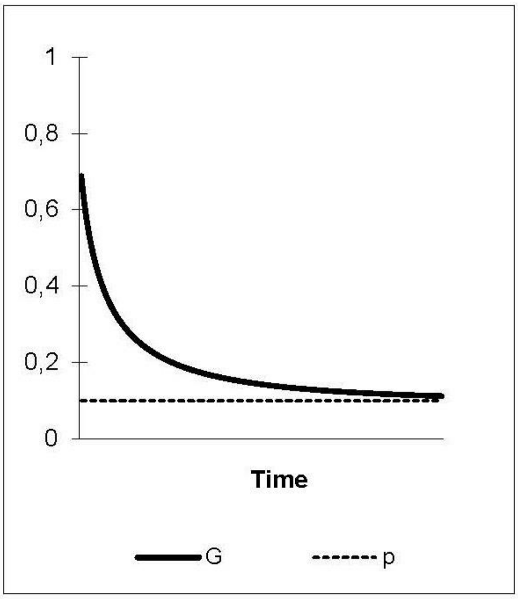

Figure 1. The fading effect
($\alpha_1 = 0, \eta = 0, \gamma_{ab} = 0, \mu = .2, \delta = 0$)

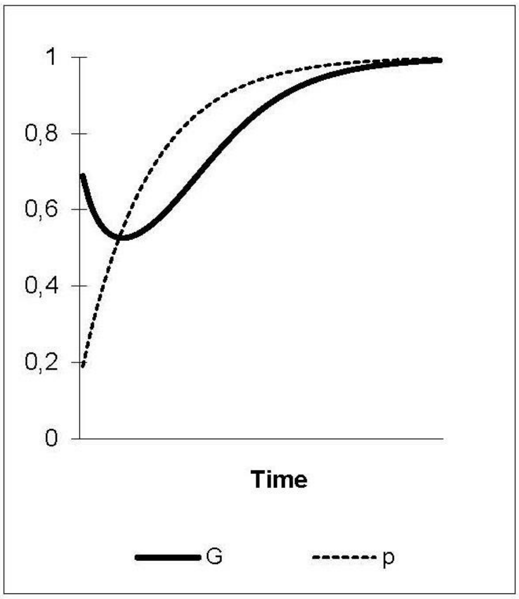

Figure 2. The influence of role models
($\alpha_1 = .1, \eta = 0, \gamma_{ab} = 0, \mu = .2, \delta = 0$)

As shown in Figure 2, the relatively modest increase of M1’s influence as compared to the “fading scenario” (with $\alpha_1 = 0$) leads to the rapid spreading of the “green” preference a in the population. Shifting some weight in model-based social learning from peers toward a “green” role model or media causes a slight increase in the adoption probability of a. Its frequency is raised in the population in the next time step including M2 and M3. Thereby, M1 initiates the transition toward a “green” consumption regime. However, the growing number of a-types among the highly weighted, directly interacting peer models M2 and M3 is a prerequisite for this dissemination process to happen. If these agents were unwilling to switch preference, for example, due to a strong hedonistic learning bias favoring b, a would not spread. Hence, a combination of strong group-bound social learning with a dedicated “green” model’s stimulus is necessary to overcompensate the “fading effect” by inducing persistent preference change on the part of consumers. This translates into overt “green” behavior with $p = G$ in the long-run: agents’ socially malleable preferences reverse the decline of overt “green” behavior. We also see that relative to the spreading of the “green” preference a, the increase of the frequency of overt “green” behavior, G, is lagged. This indicates a temporary action-value-gap: while agents are endowed with preferences for pro-environmental behaviors, not all of them act according to these (e.g., Babutsidze & Chai 2018). Consumers may need some time to adapt their lifestyles or to overcome habits and norms. This gap closes as more and more agents learn to act in line with their “true” acquired preference. Consequently, “enhanced green nudges” incorporating model biases at different societal levels have the potential to sustainably move the population toward a pro-environmental consumption regime, without changing monetary incentives or the option set itself.

An attempt to draw on the model bias are home energy reports that contain energy-saving achievements by an anonymous poster household (e.g., Allcott 2011). However, since this abstract learning environment does not present “socially rich” contents, such as, for example, concrete models from one’s peer group or visible as well as assignable behaviors, biased cultural transmission fails to induce persistent changes in preferences. As a result, the “nudge’s” effect faded. In line with this evidence, Fischer (2008) finds that for changing a household’s electricity consumption in a lasting manner, conscious decisions in this direction are required that involve social learning along visible features of “green” models as well as direct communication with peers. Moreover, in experimental settings, “nudging” strategies that involve concrete role models have been shown to be relatively more effective in modifying consumption behavior (see Ayres et al. 2013). Tangible role models agents identify and empathize with exert great influence on individuals’ behavior: as a case in point, marketing campaigns use prominent celebrities in their advertisements to convince consumers to buy certain products (e.g., Erdogan 1999). This powerful force in social learning can also be harnessed to disseminate “green” behaviors (e.g., van den Bergh 2013). Therefore, the model-based bias is a suited cognitive component of an “enhanced green nudge” meant to modify agents’ choice behavior as well as the underlying preferences. The bias’s impact in cultural transmission is, however, predicated on the characteristics of the learning environment it operates in. Evolved cognitive learning dispositions are most effective in environments resembling those from which they emanated during human phylogeny.

A further scenario accounts for the interaction of a “nudge’s” decay, an individual direct learning bias favoring behavior B, and conformity as a component of an “enhanced green nudge”. Conformity is another influential force in group-bound social learning and a typical characteristic of an ancient learning environment with intense social interaction. This evolved cognitive disposition draws on the observed frequency of stable behaviors and corresponding preferences in a reference group. Agents then tend to adopt those exhibited by the majority. In this way, the conformity bias strongly affects the composition of individuals’ sets of preferences. In Figure 3, the fading “nudge” effect ($\mu = .2$) together with individual learning favoring preference b ($\gamma_{ab} = .2$) cause the level of overt “green” behavior, G, as well as the share of the “green” preference a, measured by p, to decline in the population. Absent social learning forces that act against these effects, the “green” preference cannot spread in the population.

Strong conformity ($\eta = .7$) can, however, overcome this simultaneous decay of G and p, as illustrated in Figure 4: the dedicated model M1 that exclusively exhibits the "green" preference a in combination with a-types among peer models M2 and M3 constitute sets of role models where a is the more frequently exhibited trait.[8] The conformity bias then spurs the dissemination of the "green" preference causing the population to lock-out of a regime of low shares of a among consumers. Moreover, the increasing share of preference a among local peers M2 and M3 accelerates the dissemination of the environmentally begin behavior. The rate of diffusion slows down again as the variance of a in the population decreases in the course of its proliferation. Finally, a high level of the environmentally begin behavior A, measured by G, is reached. Thereby, the "green" preference, spreads following a typical S-shaped path of diffusion (see Rogers 1983). As also illustrated by Figure 4, weak conformity ($\eta = .2$) – potentially reflecting a more abstract learning environment – does not suffice to induce preference learning on the part of consumers that exceeds a critical threshold beyond which it would spread further in the population. G^* and p^* continuously decrease in time.

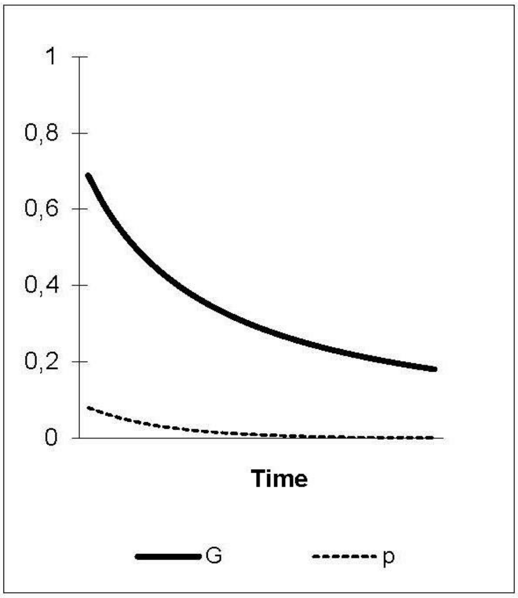

Figure 3. The hedonistic learning bias
($\alpha_1 = 0, \eta = 0, \gamma_{ab} = .2, \mu = .2, \delta = 0$)

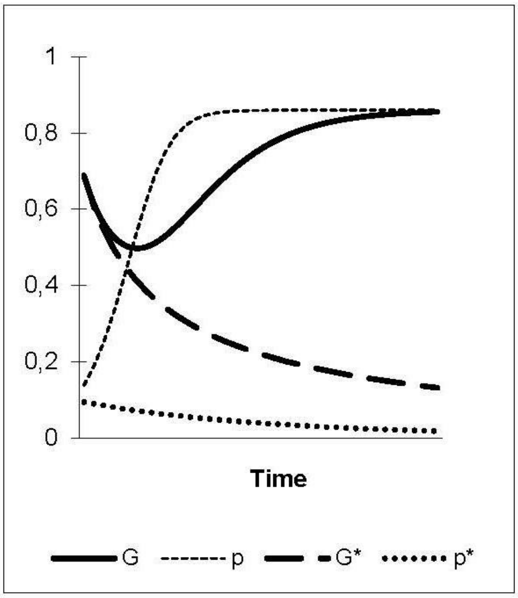

Figure 4. The conformity bias
($\alpha_1 = 0, \eta = .2/.7, \gamma_{ab} = .2, \mu = .2, \delta = 0$)

Consequently, the conformity bias is another important aspect of social learning-based preference acquisition in "natural" learning environments and thus an effective component of an "enhanced green nudge". Empirical evidence shows that the probability of agents to adopt "green" behaviors and underlying preferences is positively correlated with the number of adopters among their local peers (e.g., Welsch & Kühling 2009). Nolan et al. (2008) show that the visible energy conservation behavior of the majority of an agent's neighbors motivates people to conserve more energy. This effect turned out

[8] M1's influence exclusively manifests through the conformity bias ($\alpha_1 = 0$).

to be the strongest amid other instruments Moreover, conformity combines with norm-following behavior: agents are normatively disposed to stick to the majority behavior (see Cialdini & Goldstein 2004). Norms relating to pro-environmental behaviors frequently emerge within local reference groups where a majority of peers supports them and corresponding actions are easy to observe (see Babutsidze & Chai 2018). Sets of group-specific “green” norms are then stabilized by conformity as well as norm-following behavior and vary across regions’ idiosyncratic cultural environments. Both forces can, however, also stabilize environmentally harmful behavioral equilibria. Pioneer adopters as prestigious role models are then necessary to introduce pro-environmental behavior to the group to initiate a shift in local norms (also Welsch 2022).

The following propositions capture the implications of our scenario-based findings. Proposition 2 highlights the potentially great effectiveness of “enhanced green nudges” including a role model, norm-following, self-similarity, or conformity bias in initiating enduring shifts in agents’ preferences:

Proposition 2: *“Enhanced green nudges” that incorporate social learning biases based on evolved cognitive dispositions can effectively induce persistent changes in consumers’ preferences toward environmentally begin behaviors.*

Biases’ impact in cultural transmission is mediated by the learning environment. If its characteristics resemble those biases evolved from, the latter’s influence is enhanced. The features of an individual’s learning environment, therefore, strongly affect which information enters the deliberate acquisition of preferences. Consequently, our third proposition reads:

Proposition 3: *Learning environments resembling those biases evolved from during human phylogeny are a prerequisite for “enhanced green nudges’” effectiveness.*

4.3. A default-based preference inducement effect

Our final scenario introduces an “inducement effect” as a special feature of default-based “nudges”. It can cause permanent shifts in agents’ preferences: pro-environmental behaviors established by these “nudges” then translate into the adoption of corresponding “green” preferences. Agents develop preferences for default options due to a “status quo bias” that combines “endowment effects” with “loss aversion”. To formally analyze the “inducement effect’s” potential impact in preference learning, consider a scenario as depicted by Figure 5. Starting from the situation in Figure 3 that includes individual learning and a “nudge’s” fading process, this scenario shows how the inducement of “green” preferences through a default-based “nudge” can, *ceteris paribus*, significantly raise the level of the environmentally begin behavior A in the population.

Given the parameter constellation in Figure 5 that includes an “inducement effect” ($\delta = .2$), the frequency of a, denoted by p, is higher as compared to the reference scenario.

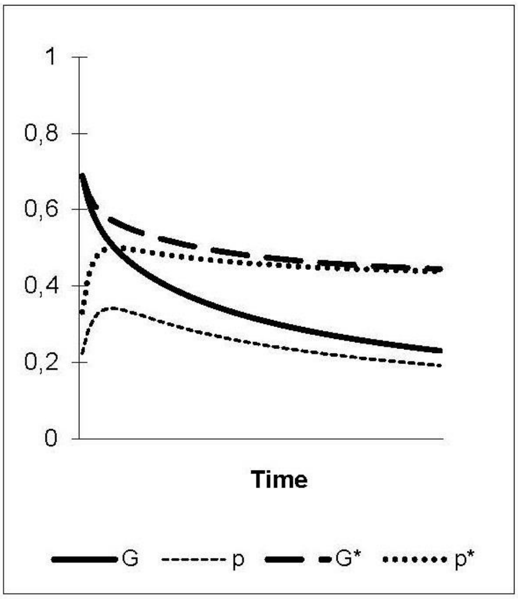

Figure 5. The inducement effect
($\alpha_1 = 0$, $\eta = 0$, $\gamma_{ab} = .2$, $\mu = .2$, $\delta = .2/.35$)

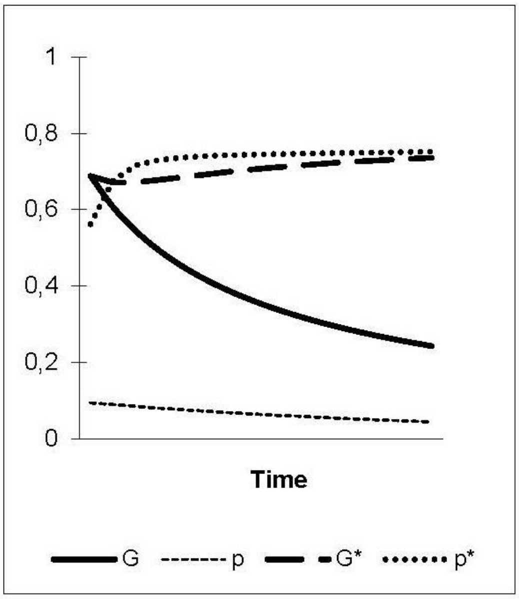

Figure 6. Conformity and inducement
($\alpha_1 = 0$, $\eta = .2$, $\gamma_{ab} = .2$, $\mu = .2$, $\delta = 0/.6$)

However, after an initial peak, the share of the “green” preference still is continuously decreasing in the course of time. For a stronger “inducement effect” ($\delta = .35$), however, the shares of p^* and G^* reach a stable equilibrium at $\hat{p} \approx .43$.

Preference inducement by preset options may be used by environmental policy to lead consumers out of a lock-in situation to environmentally harmful behavior toward “greener” consumption patterns. To formally illustrate this, Figure 6’s starting point is the second setting shown in Figure 4: given individual learning and fading processes, conformity alone is not strong enough to establish a high share of preference a and overt “green” behavior G among agents. When, however, combined with a default-based “inducement effect” ($\delta = .6$) that leads to more a-types in sets of models, conformity is sufficient to introduce a high level of environmentally begin behavior, p^* and G^* in Figure 6, to the population. The “inducement effect” shifts the preference acquisition dynamic to the point beyond which a starts to spread. Proposition 3 states:

Proposition 4: *By the inducement of preference learning through specific cognitive biases, default-based “green nudging” promotes the dissemination of environmentally begin behavior in a population of consumers.*

5. Conclusion

Most “green nudges” do not induce persistent change in consumers’ preferences, but merely trigger short-term behavioral adaptations that are subject to decay. In contrast, “enhanced green nudges” have the potential to effectively foster consumers’ acquisition of stable environmentally begin preferences. They incorporate powerful social learning biases, such as a role model bias, self-similarity, norm-following, or conformity, that are based on evolved cognitive dispositions of human agents. To a great extent, these determine which cultural information enters agents’ process of preference acquisition. The effectiveness of “enhanced green nudges” is, however, mediated by the characteristics of learning environments: if it incorporates features of environments biases evolved from during humans’ phylogenetic past, these dispositions exert great influence in cultural transmission. Core features of these ancient settings have been direct interaction and face-to-face communication in small-group contexts as well as visibility, saliency, and assignability of peers’ behaviors. Since most human cognitive dispositions evolved in the context of bands (Henrich 2016), biases in social learning are especially powerful in environments characterized by features of “small group interactions”. Therefore, when implementing “enhanced green nudges” as a political tool, a central task for politicians is to create learning environments that boost their effects.

Given these insights into “enhanced green nudges”, some implications for environmental policy making can be derived. For example, a political initiative meant to promote “green” choice based on a role model and a self-similarity bias could comprise the following features: (1) the organization of direct communication between dedicated and acknowledged “green” experts and interested individual pioneer adopters, institutions, or firms about the environmental (and economic) characteristics of new “green” commodities or services. Potentially, this induces the acquisition of a “green” preference by first movers and the adoption of the pro-environmental novelty. Fairs, exhibitions, or competence centers could be (state-aided) frameworks for such an exchange of knowledge. (2) The early “green” adopters, in turn, introduce the environmentally begin behavior to their local group of self-similar peers by means of face-to-face contacts and direct communication. Due to past forward-looking behavior and corresponding success, these pioneers may have earned some prestige within their group. As this is an essential trait for an indirect role model bias to take effect in cultural transmission, these key agents then spur the dissemination of the new “green” behavior.

To provide another political implication, pecuniary incentives given by the government to promote initial adoption of environmentally begin products or services increase their visibility in local groups. They also suggest a state-backed new consumption norm. Direct communication of (self-similar) peers triggered by this increased visibility spreads knowledge about the features of this novelty as well as the reasons for implementing it as a new behavioral norm. Individuals’ evolved psychological inclination to follow norms then disseminates the corresponding “green” behavior. This may happen even if the new behavior bears some additional costs: the psychic force emanating from the norm-following disposition would then dominate pecuniary motives. Moreover, if a "critical mass" of norm adopters is surpassed in the peer group, conformity accelerates the further diffusion of the "green" alternative. In addition, norms are defined in the context of societal debates. Politicians, the media, scientists, celebrities, environmental interest groups, or pioneer users are part of this norm creation process. "Green" norms can be made more salient by these prestigious models by engaging in these debates and by broadly integrating local societal groups. Moreover, a shift in a group's norms toward environmentally begin behaviors opens up the possibility of "green" status races based on directly biased cultural transmission: "enhanced green nudges" that are based on consumers' desire to display "green" status through environmentally begin consumption to peers would be an effective instrument (also Schubert 2017). Electric cars, for example, can – as a "green" positional good – indicate a progressive sustainable lifestyle (e.g., Delgado, et al. 2015).

The bulk of information humans as cultural beings process originates from social learning mediated by characteristics of the learning environment. To a great extent, individuals' preferences are formed on this informational basis. This explains why "enhanced green nudges" are more effective in changing consumers' preferences: they draw on biases in cultural transmission predicated on cognitive dispositions with deep evolutionary roots in human phylogeny. Hence, in combination with a suited learning environment, this class of "nudges" represents a powerful political instrument to induce agents to adopt preferences for environmentally friendly commodities and services.

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