GAMIFYING GREEN:

Gamification and Environmental Sustainability

This is an (early) draft chapter for the forthcoming book *The Gameful World.* This draft clocks in at a rather verbose 22,000 words while the final version is around 13,000. Please order the published version at gamefulworld.org or Amazon.com (link). Note: I originally wrote this chapter in January 2013 though the book was not published until January 2015. The pagination, article double spacing, figure and table placement are for draft purposes and will be handled by the publisher for the final print version.

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Gamifying Green

Surveying and Situating Green Gamification and Persuasive Technology for Environmental Sustainability

Jon Froehlich

Introduction

In their *State of Green Business* report, the GreenBiz Group listed gamification as one of the top sustainable business trends of 2012, noting that game mechanics are increasingly used by companies to provide "rewards for making good, green choices" (Makower 2012). In the last few years, we have seen a surge of interest in green gamification, which is beginning to touch upon nearly all aspects of our everyday life from cars that rank and reward fuel-efficient driving performance (*e.g.,* the Nissan Leaf) to sanitation services that monitor and reward home recycling behavior (*e.g.,* Recyclebank). As Ashok Kamal, the CEO of the green social media marketing company Bennu notes, this movement represents a "tidal wave of green gamification that is capturing the attention of the green community and the business community as a whole" (Cousteau et al. 2012).

Given such vibrant enthusiasm surrounding "green gamification," it is hard not to react with some degree of skepticism. Climate change, pollution, and other human-driven environmental ills are complex, multi-faceted problems—can gamification actually play a serious role in their solution? In this chapter, I attempt to provide a partial answer. I survey the rise of gamification as a mechanism to encourage proenvironmental behavior[1] and connect it back to similar behavior-based movements in environmental psychology and persuasive technology. While games have long been used to teach sustainability concepts *(e.g.,* Chris Crawford's 1990 *Balance of the Planet*), the focus of this chapter is purely on the link between sustainability and *gamification*—the use of game design elements in traditionally non-game contexts (Deterding et al. 2011).

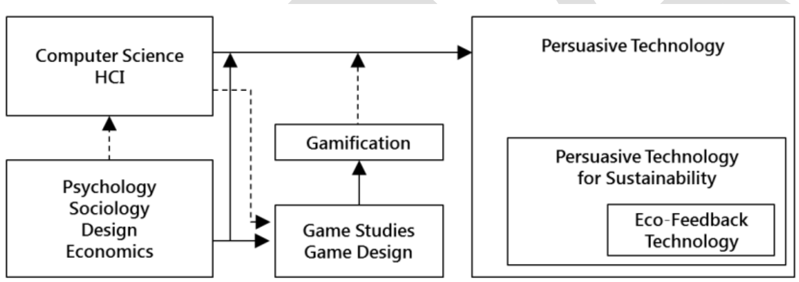
My goal is not to advocate or champion the use of gamification in environmental contexts but rather to provide disparate perspectives, to provoke thought, and to outline successes and failures. In the interest of full disclosure, I have myself designed, experimented with, and evaluated technology-mediated game mechanics in the context of "green" behaviors (Froehlich et al. 2012; Froehlich et al. 2009); however, my hope is to provide a critical perspective that is enriched by these experiences rather than biased by them. In addition, unlike Eric Zimmerman, Ian Bogost, Jane McGonigal, and many others with a high profile in gamification discourse, I am not a game designer nor a game/media scholar but rather a computer scientist who works at the intersection of human behavior and technology, often with respect to environmental sustainability and personal health and wellness (*e.g.,* see Froehlich, Findlater, and

[1] It is not always clear what, exactly, constitutes proenvironmental behavior. Here, we borrow from Stern (2000b) and Steg and Vlek (2009) who define *environmental behavior* as any behavior that changes the availability of materials or energy from the environment or alters the structure and dynamics of ecosystems or the biosphere and *proenvironmental behavior* as any behavior that harms the environment *as little as possible.*

Landay 2010; Froehlich et al. 2012; Hekler et al. 2013; Consolvo et al. 2008). My perspectives, then, are not grounded or shaped by game and media scholarship but rather by my background in human-computer interaction, computer science, and design.

Contextualizing Green Gamification

At its core, gamification is a persuasive approach. It is the application of game design elements to help achieve a particular *designed* agenda or goal: for example, to increase user interest, sustain attention, or provoke specific behaviors. Although gamification has long-existed in various forms (*e.g.,* loyalty marketing programs), it is only through the massive adoption and availability of computing—including the Internet, fast computation, and cheap, pervasive devices—that gamification has become a viable strategy for influencing *everyday* behaviors. Within the realm of environmental sustainability in particular, gamification is used as a set of motivational techniques to inspire and provoke proenvironmental interest and action. This is typically achieved by using sensed information to visualize and reward particular behaviors (*e.g.,* energy-efficient consumption in the home). This section provides an overview of the larger research areas that intersect with green gamification, including persuasive technology, eco-feedback, and environmental psychology. I specifically focus on parallels between these areas before using them as a backdrop to situate and contrast gamification in particular. To start, please refer to Figure 1, which provides two conceptual illustrations for the relationship between gamification and persuasive technology for sustainability.



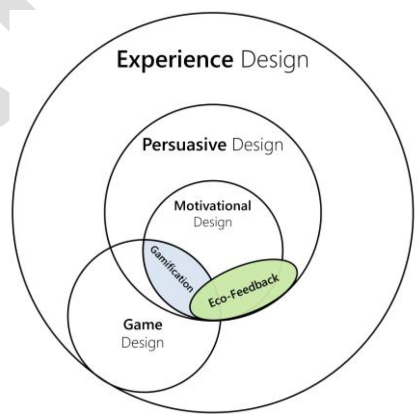


Figure 1: Two conceptual illustrations depicting the role of gamification in persuasive technology. While both draw upon theories and concepts from psychology, sociology, economics, and design, gamification is uniquely influenced by game scholarship and game design. Gamification is thus the application of game-mechanics and related gaming principles to persuasive technology.

Persuasion and Persuasive Technology

The idea and study of persuasion dates back to ancient Greece. The term *rhetoric*, which refers to the art of persuasion, first appeared in Plato's *Gorgias* written in 380 BC. While for the ancient Greeks rhetoric existed as a written or oratorical form, the emergence of photography and cinema in the 19th and 20th centuries led to a new rhetorical movement: *visual rhetoric*—that is, the study of how and in what ways images persuade. Hill (2004) suggests that unlike verbal text, which is apprehended relatively slowly and involves systematic processing, images are comprehended holistically and rely more on emotional response than reasoning. Now, with the rise of the information age, a new persuasive form has emerged: computers—not just as passive mediators of persuasion (*e.g.,* like television) but as *interactive* and *proactive* systems of persuasion. And, as with previous persuasive forms, a new discipline has emerged to design, study, and critique computers that persuade.

In the late 1990s, BJ Fogg and his colleagues at Stanford University pioneered research in this area (Fogg and Nass 1997; Fogg 1997b; Fogg 1997a; Fogg 1998). Their work culminated in a seminal book entitled: *Persuasive Technology: Using Computers to Change What We Think and Do* (Fogg 2003). Here, Fogg defines persuasive technology[2] as "any interactive computing system designed to change people's attitudes or behaviors" (1). See Figure 2. To Fogg, *interactivity* is one of computing's primary advantage over previous forms of persuasive media (Fogg 2003, 6); just as a skilled human persuader can adapt their tactics to fit a particular situation or person, Fogg argues that persuasive technologies have the promise of adjusting their output based on evolving user needs and contexts (a strategy relevant to the design of gamification as well). Although only a nascent field in the late 1990s and early 2000s, persuasive technology has quickly grown to become a common part of the modern technological landscape from smart phone applications that motivate us to exercise (*e.g.,* Runkeeper) to digital thermostats that encourage energy-efficient HVAC settings (*e.g.,* Nest).

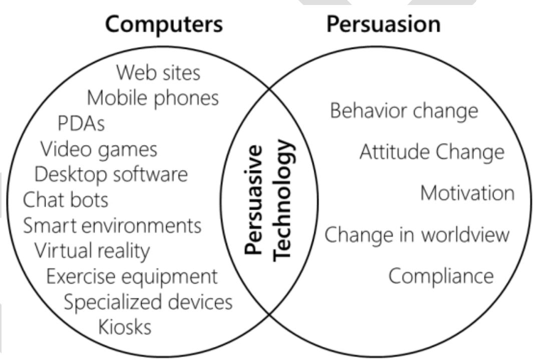


Figure 2: Fogg's original conception of persuasive technology (*i.e.*, where computing technology and persuasion overlap)—slightly modified from (Fogg 2003). As computing begins to pervade even more aspects of our life (*e.g.*, smart watches, Google Glass, e-ink displays, e-textiles), there is even greater opportunity for technology to *persuade*—whether for good or for bad.

[2] In 1997, BJ Fogg helped convene a special-interest group meeting on persuasive technology at CHI, the top conference in human-computer interaction. There, a group of participants agreed to call this emerging field *captology*, built from the acronym **C**omputers **A**s **P**ersuasive **T**echn**ology** (Fogg 1997b). Although used occasionally, this term has not been widely embraced. Instead, persuasive technology is often used to describe the field as well as the designed artifact. Fogg's own lab at Stanford is called the "Persuasive Technology Lab."

Principle	Description
Reduction	**Persuading through simplifying:** making a behavior easier to perform increases the benefit/cost ratio of the behavior and increases the likelihood that the behavior will occur and occur with more frequency (*e.g.,* Amazon's one-click purchasing) (Fogg 2003, 33).
Tunneling	**Guided persuasion:** tunneling controls what the user experiences—the content, possible pathways, the nature of their activities—and thus can persuade users to take certain actions (*e.g.,* the tightly constrained check-out sequence on Amazon) (Fogg 2003, 34).
Tailoring	**Persuasion through personalization:** information that is tailored to an individual's needs, interests, personality, usage context, and other relevant factors increases its persuasiveness (*e.g.,* Amazon's personalized recommendations for purchases) (Fogg 2003, 37).
Suggestion	**Intervening at the right time:** related to the Greek persuasion principle kairos (καιρός), a computing technology will maximize its persuasive power if it offers a suggestion at opportune moments (*e.g.,* Amazon takes you to a recommendation screen once you add an item to your cart). (Fogg 2003, 41).
Self-monitoring	**Taking the tedium out of tracking:** computing technology can automatically measure and track performance about a target behavior, which increases the likelihood that the behavior will persist towards a goal or outcome (*e.g.,* Runkeeper, Fitbit, Nike+) (Fogg 2003, 44).
Surveillance	**Persuasion through observation:** computing technology that allows one party to monitor the behavior of another has the ability to influence said behavior (*e.g.,* Fogg cites Hygiene Guard, which monitors hand washing in employee restrooms and automatically records infractions) (Fogg 2003, 46).
Conditioning	**Reinforcing target behaviors:** computing systems can use principles of operant conditioning to change behaviors (*e.g.,* Fogg cites Telecycle, an exercise bike that blurs the images of a TV when the user slows down thereby providing an incentive to ride at a target pace) (Fogg 2003, 49).

Table 1: Fogg's seven principles of computers as persuasive tools (Fogg 2003). Although each have some implication for the design of gamification systems, tailoring, suggestion, self-monitoring, and conditioning are most relevant.

Fogg enumerates seven design principles for persuasive technology that are derived from behavioral psychology (Table 1). Though the list is over a decade old, there are clear intersections with and implications for gamification. For instance, one key principle is the idea of *self-monitoring*: the use of technology for self-tracking and feedback and is the core of many gamification and persuasive technology systems. At a high-level, these systems are comprised of two parts: a *sensing* component that monitors behaviors and a *visualization* component that provides feedback on those behaviors. For example, the Fitbit wearable sensor tracks and displays step counts and caloric expenditure and provides a virtual flower that grows in proportion to recently sensed activity level.

Not all *sensing* and *feedback* systems are persuasive, however. Consider a traditional analog speedometer in a car. The display provides instantaneous feedback about speed but it is meant to be *informative* rather than *persuasive*. In comparison, more recent dashboard designs like the Ford SmartGauge and Honda Eco-Assist are specifically built to persuade fuel-efficient driving behaviors. This brings about two critical and interwoven issues related to persuasive technology: (i) there is a spectrum between neutrally conveyed information and information that is conveyed with *persuasive intent* (ii) this intent is ascribed by the designer him or herself with a specific goal or set of goals in mind. Gamification, as a rhetorical form, can transform an otherwise neutrally-portrayed information display to a persuasive one. The two aforementioned dashboards are persuasive technologies that directly rely upon gamification strategies to increase driver engagement with and performance towards fuel-efficient behaviors. They are also examples of *eco-feedback technology*, a specific form of persuasive technology designed to promote proenvironmental attitudes and behaviors (Froehlich, Findlater, and Landay 2010). We will return to these in-car dashboards (and others) later in the chapter. As eco-feedback is, perhaps, the most prominent form of persuasive technology for sustainability and represents many of the examples in this text, it deserves further explanation.

Eco-feedback technology is based, in part, on the working hypothesis that most people lack understanding about how their everyday behaviors such as showering and commuting to work affect the environment and that technology may bridge this "environmental literacy gap" by automatically sensing these activities and feeding related information back through computerized means (*e.g.,* mobile phones, ambient displays, or online visualizations). However, eco-feedback is not just about solving an *informational* problem (*i.e.,* a presumption that people would necessarily act more proenvironmentally if they were more aware or more informed) but also a *motivational* one. That is, how can we visualize sensed information in a way that not only informs but also motivates action? This is, of course, a chief objective of many gamification implementations as well. As a final note, while this chapter focuses on eco-feedback, not all persuasive technology promoting proenvironmental behavior falls into this category. Take, for example, an interactive banner advertisement on a website for green lighting (*e.g.,* LED or CFL lights); this banner may be persuasive, ultimately motivating the user to buy new lighting, but it does not provide feedback on sensed behavior and thus is not strictly eco-feedback technology.

Environmental Psychology

Eco-feedback is informed not only by persuasive technology (and underlying behavioral theories and principles) but also by environmental psychology, which is the twofold study of how the environment affects human behavior and how human behavior affects the environment[3]. Though environmental psychology dates back to the early 1900s, the shift towards studying the interplay between behavior and environmental sustainability occurred in the 1970s and 80s (Pol 2006)[4]. While this research provides numerous lessons for the design of eco-feedback and green gamification (*e.g.,* in identifying barriers to proenvironmental behavior, in understanding the link between proenvironmental attitudes and behaviors), there are two particularly applicable threads of work. First, the identification and study of *determinants* of proenvironmental behavior—that is, *why* people hold proenvironmental beliefs and behave in a proenvironmental fashion. And, second, the study of financial and non-financial motivational techniques for encouraging proenvironmental behavior—that is, *how* can we influence and effectively promote proenvironmental decision-making and action.

Understanding why people engage in environmentally responsible behavior is a complex topic spanning disciplines such as education, economics, sociology, psychology, and philosophy. Although numerous theoretical models of proenvironmental behaviors have been developed and studied, no definitive explanation has yet been found (Kollmuss and Agyeman 2002). Still, these models offer insights into why

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[3] Environment need not mean the "natural" environment but also the built environment. Pol refers to the third stage of environmental psychology as *architectural psychology* precisely because of its focus on built surroundings.

[4] Given that environmental psychology is not simply focused on the relationship between human behavior and environmental sustainability, a number of researchers have used or proposed other names to describe this specific sub-discipline including "green psychology" (Pol 1993), "natural psychology" (Gifford 1995), "conservation psychology" (Saunders 2003), and "eco-psychology" (Howard 1997). Pol suggests using the label "environmental psychology" (as I do here) despite its more broader meanings because it is easily understood and hides the internal subtleties and debates of the field (Pol 2007, 20).

people act environmentally, and thus, have direct implications for the design of eco-feedback and green gamification systems. Stern (2011) highlights two dominant theories of proenvironmental behavior: the first emphasizes individualistic motives and presumes that individuals seek to maximize their material welfare, subjective well-being, or utility. The rational-economic model, for example, assumes that people act to maximize rewards and minimize costs. The second set of theories involves factors beyond individualism such as environmental consciousness (*e.g.,* eco-centrism) and altruism. For example, Schwartz's moral norm-activation model (Schwartz 1977) suggests that proenvironmental behavior can be stimulated if a person is aware of the negative consequences for others and ascribes some amount of responsibility for taking ameliorative action. Stern notes that these two perspectives are not mutually exclusive and that both theories—those more egocentrically leaning and those more pro-socially leaning—have explanatory value across a range of proenvironmental behaviors (Stern 2011).

While these models of behavior provide designers with different theoretical approaches with which to build persuasive technology systems (with or without gamification), they do not offer specific strategies for changing behavior (*i.e.,* how does one move from apathy to action). Environmental psychologists have studied the effectiveness of a number of techniques for motivating proenvironmental action, many of which overlap with gamification strategies including goal setting, social comparisons, modeling, and rewards (*e.g.,* see McKenzie-Mohr 2011). The most popular behavioral interventions are summarized in Table 2.

In many cases, the above techniques can be combined with other principles from behavioral psychology and behavioral economics (*e.g.,* Tversky and Kahneman 2007) including loss aversion, social norms, reciprocity, scarcity, and anchoring. Loss aversion, for example, refers to a behavioral bias towards avoiding losses compared to acquiring gains (Tversky and Kahneman 1991; Kahneman, Knetsch, and Thaler 1991)—some studies suggest that the threat of a loss has *twice* the motivational potential as the promise of a gain with greater effects in competitive environments (Gill and Prowse 2012). Applied to the environmental domain, a study by Gonzales, Aronson, and Costanzo (1988) found that framing energy choices in terms of avoiding losses rather than achieving gains persuaded homeowners to take greater advantage of financial subsidies for home weatherization. As a second example, Goldstein, Cialdini, and Griskevicius (2008) found that providing a *descriptive social norm* message about how the majority of hotel guests reuse towels increased towel reuse by 34%. A descriptive social norm describes what is typical or normal behavior in a particular context: "If everyone is doing it, it must be a sensible thing to do" (Cialdini, Reno, and Kallgren 1990). Cialdini argues that this presumption offers an information-processing advantage in the form of a decisional shortcut—observing others and imitating their actions is often a prudent, sensible choice (Cialdini 2008). See (Wilson and Dowlatabadi 2007) for further discussion of behavioral economics applied to proenvironmental behavior.

Intervention Technique	Description
Information	*Information* is perhaps the most widely used means to promote proenvironmental behavior (*e.g.,* pamphlets, websites, public-service announcements). Studies have shown, however, that simply presenting information can increase knowledge but generally has minimal effects on proenvironmental behavior (Katzev and Johnson 1987; Gardner and Stern 2002). To maximize information's persuasive potential, it must be easy to understand, prescriptive, trusted, presented in a way that attracts attention and is remembered, and delivered as close as possible in time and place to the relevant choice (Brewer and Stern 2005).
Comparison	A *comparison* between individuals or groups can be useful for motivating action. However, the way in which social comparisons are conducted (*e.g.,* which groups are used for the comparison, whether there is an explicitly structured competition) and how these comparisons are visualized can significantly impact their effectiveness (Siero et al. 1996 *vs.* Haakana, Sillanpää, and Talsi 1997; Egan 1999). Comparisons can also be to self (e.g., historical performance) or to a goal.
Incentives & Rewards / Disincentives & Punishment	Financial *incentives* have been used successfully across a broad range of proenvironmental behaviors such as increasing recycling behavior, properly disposing of toxic waste, and installing solar photovoltaic systems (McKenzie-Mohr 2011, 112-115). Non-financial incentives can also be used, such as reducing time and effort or offering social recognition (*e.g.,* curbside recycling *vs.* recycling centers, express lanes for buses and carpools). Alternatively, disincentives such as surcharges on plastic bags (Harvey 2013) or tiered energy pricing (Alberini and Filippini 2011) can be effective.
Commitments/ Goal-setting	Commitments and goal-setting affects behavior primarily by increasing attention, effort, and persistence toward goal-relevant activities (Locke and Latham 2002). For example, both Becker (1978) and Howelingen and van Raaij (1989) found that goal-setting in conjunction with feedback resulted in a 12-15% reduction in energy usage compared to a control group. The influence of a goal can vary based on *who* set the goal (*e.g.,* self-set or externally set) and the goal's difficulty (*e.g.,* typically, more challenging goals have greater effectiveness as long as the individual feels that s/he can complete the goal.
Feedback	Many of the above techniques either require or can be enhanced by behavioral *feedback* (*e.g.,* goal-setting requires feedback about progress towards a goal). Feedback appears to work because it has both informational and motivational properties: it provides a basis for assessment and action, and enables progress towards a goal (Aitken et al. 1994; Fischer 2008). For example, in a meta-review of 57 residential energy usage feedback studies, households reduced electricity consumption by 4-12% on average (Ehrhardt-Martinez, Donnelly, and Laitner 2010). In another survey, Fischer found that the most effective interfaces provided multiple feedback options (e.g., over various time periods, comparisons), were updated frequently, were interactive, and/or provided an appliance-specific breakdown of usage (Fischer 2008).

Table 2. A list of common intervention techniques used in environmental psychology to promote proenvironmental behavior. For more detail, see Allcott and Mullainathan 2010; McKenzie-Mohr 2011; Gardner and Stern 2002

Where does Gamification Fit?

As you may have observed, many persuasive technologies and interventions in environmental psychology employ motivational techniques similar to those associated with gamification. Historically, however, these techniques were not explicitly recognized as gamification, but instead were tied to more core theoretical underpinnings from psychology, sociology, and economics. The lack of direct attribution to gamification reflects both the recency with which the term came into being as well as a tendency by some designers to reject the term as hype or ill-fitting (*e.g.,* Bogost 2011). In my experience, it also reflects a general confusion about what is and is not gamification and how gamification differs from other motivational strategies used in persuasive technology.

Deterding and colleagues argue that: "…'gamification' does indeed demarcate a distinct but previously unspecified group of phenomena, namely the complex of playfulness, playful interaction, and gameful design" (Deterding et al. 2011, 2). To me, the clearest distinction between a traditional persuasive technology and a gamified one is this notion of *designed playfulness*—turning to games to learn about and apply notions of fun, competition, and narrative in design. Though the term "gamification" itself remains controversial, its emergence has established a common vocabulary and context with which we can describe, study, and discuss related "gamified" systems. This design language, however, is also a source of confusion in the context of persuasive technology because similar phenomena may be referred to with different names: *e.g.,* "progress tracking" and "badges" in gamification may be referred to as "feedback" and "virtual rewards" in persuasive technology. Of course, a gamified badge system and a non-gamified progress tracker may be operationalized, implemented and visualized differently, with the gamified version emphasizing fun and playfulness. In addition, some aspects of game design have been underexplored in persuasive technology and gamification helps uncover such insights, including the use of uncertainty and unpredictability to create and sustain engagement, the use of storytelling or narrative, and the use of deliberate gaps in a design or message that the user will want to fill (*e.g.,* see Koster 2004; Chatfield 2010; Lockton 2010).

So, while I agree with Deterding et al. that gamification demarcates a unique set of design phenomena related to games, this demarcation is also perhaps more nuanced than the aforementioned quote implies. For example, the Toyota Prius eco-feedback display, which will be discussed in detail later, provides drivers with real-time feedback on "eco-driving performance" but lacks specifically designed gamified elements. In contrast, newer cars such as the Ford SmartGauge and Honda Eco-Assist were explicitly designed with gamification elements such as social comparisons, competitions, trophies, and avatars to motivate fuel-efficient driving behavior. However, interestingly, in both cases, some drivers perceived the displays as providing a game-like experience. Thus, as you will encounter below, simply providing basic mechanisms—like behavioral feedback—can be enough to inspire game-like reactions and behaviors.

In my survey of green gamification below, I include historical systems designed prior to the emergence of gamification as well as more recent systems, which may or may not be self-described as "gamification" but seem to include aspects of game mechanics in their design. I feel it best not to get lost in a philosophical debate between what is and what is not gamification. Instead, I will lean towards inclusion if for no other reason than to provoke discussion and provide historical context.

Gamifying Green Examples

In this section, I enumerate green gamification and eco-feedback examples in the context of three environmentally significant domains: home resource consumption, personal transportation, and waste disposal behaviors (*e.g.,* littering and recycling). An early study by Schipper et al. (1989) concluded that in the US "about 45-55% of total energy use is influenced by consumer activities for personal transportation, personal services, and homes." More recent studies estimate that home energy use and personal travel account for 28% of total US energy use and 41% of CO_2 emissions (Bin and Dowlatabadi 2005). Of course, there are other areas that deserve attention—for a start, see Oskamp (2000) who outlines the role of behavior across a broad range of areas including deforestation, species extinction, exhaustion and misuse of arable land, pollution, and human exposure to toxic chemicals. Our survey includes examples from academia and industry. While work in industry is often deployed and evaluated more broadly (*e.g.,* larger studies, longer study length), research in academia is typically more forward-looking and experimental. Thus, there is value in reviewing each.

Home Resource Consumption

Behavior has a significant impact on home resource consumption. In a study of 10 identical Habitat for Humanity all-electric homes outfitted with the same appliances and equipment, the most energy intensive home consumed *2.6 times* more energy than the least (Parker, Mazzara, and Sherwin 1996). Other research has shown similarly that energy use can differ by two to three times in identical homes occupied by people with similar demographics (*e.g.,* Socolow 1978; Schipper et al. 1989). With the rise of ubiquitous Internet connectivity, mobile and in-home displays, and smart meters[5], eco-feedback will undoubtedly play an increased role in promoting and supporting proenvironmental behavior in the home. Dietz et al. (2009) estimate that behavioral interventions could reduce carbon emissions from direct energy use in households by 20%, which is equivalent to 120 million metric tons of carbon or more than the entire emissions of France in 2005. Perhaps surprisingly, energy utilities themselves are implementing many of these behavioral interventions through their own conservation programs. While utilities are in the business of selling energy and in that regard have no incentive to drive down energy usage demand, some states have passed legislation to decouple utility profits from energy sales (see NARUC 2007). Additionally, 24 US states have enacted mandates that require utilities to reduce demand through conservation programs (ACEEE 2010).

Opower Home Energy Reports

Opower is often touted as one of the great success stories in applying behavioral science techniques to energy efficiency programs. The company works with utilities to create and send *Home Energy Reports* (Figure 3), which combine behavioral science strategies such as descriptive social norms, injunctive messages, loss language, and personalization to encourage energy efficient behaviors (Laskey and Kavazovic 2011). I will briefly describe each in turn.

For the descriptive social norms, the home energy reports compare the receiving household's recent energy usage versus both demographically similar neighbors as well as energy-efficient neighbors[6]. Additionally, to combat the *boomerang effect* (Schultz et al. 2007), where low energy users actually increase their energy use to become closer to average, Opower uses *injunctive* messaging—conveying social approval or disapproval. Households are awarded a GREAT or GOOD label on the report plus one or two smiley faces[7] for being efficient or a BELOW AVERAGE label otherwise (Allcott 2011). Interestingly, Opower initially included frownie faces for poor performing households but stopped after customer

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[5] A smart meter is simply a digital meter that measures and records usage in near real-time and allows for two-way communication between the utility and customer. In 2012, the Institute for Electric Efficiency found that nearly 33% of US households already have an electricity smart meter and that approximately 65 million will be deployed by 2015 (IEE 2012). Smart meter penetration rates for water and gas are much lower.

[6] Unlike common parlance, neighbor here is not a geographic neighbor, but a demographically similar neighbor. based on key home characteristics such as square footage, heating or cooling system, and location (Laskey and Kavazovic 2011). It is unclear if Opower's profiling extends to actual behavioral and personality characteristics of the home owners.

[7] GREAT and GOOD are discrete bins where the former is in the top 20% efficiency and the latter is between 20-50%.

complaints—people did not like feeling negatively judged (Kaufman 2009; Allcott 2011). Opower's third strategy utilizes loss aversion, which frames inefficient energy consumption in terms of a loss (*e.g.,* "you used 33% more electricity than your efficient neighbors, this costs you about $275 extra per year"). Finally, Opower uses personalization to target energy savings advice based on each household's historical energy use and demographic characteristics. Advice for a single person who rents an apartment and rarely uses home heating will be quite different from advice for a family in a large suburban home with heavy, consistent heat usage (Laskey and Kavazovic 2011).

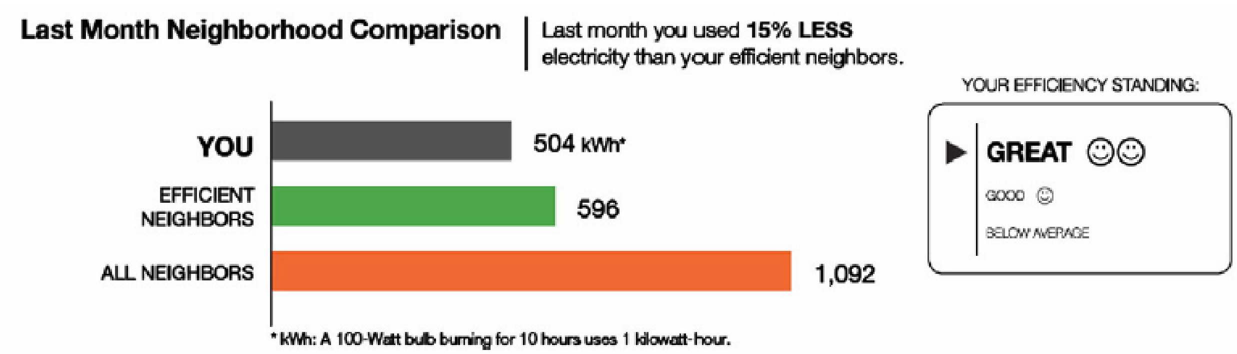

Figure 3: The top section of an Opower *Home Energy Report*, which illustrates the use of normative comparisons (the bar graph comparing the current household's usage to their neighbors). Injunctive messaging (the smiley faces) is used to mitigate the boomerang effect where both above and below average users converge towards the norm—see (Allcott 2011).

Are Opower's Home Energy Reports successful? The short answer is yes. According to their website, Opower currently has 80 utility clients and has saved over two terawatt-hours of energy worldwide since their first utility customer in 2007 (DeWitt 2013). These savings are equivalent to removing a city with a population of 500,000 people off the grid for a year. In addition, independent studies of nearly a million treatment and control households across the US have shown that utilities employing Opower's program reduce energy consumption by an average of 2%—the highest saving decile decreases usage by about 6% (Allcott 2011; Ayres, Raseman, and Shih 2009; Cooney and Provencher 2011; Wu et al. 2012).

Although Opower's approach is promising, a number of questions remain. How well do energy savings persist over time? What actions account for the savings, for example, everyday behavior changes or equipment upgrades? Can different messages motivate unengaged or under-engaged customers? With a vast reporting infrastructure in place, Opower has the unique potential to address these questions through randomized control trials (RCTs) and further increase the efficacy of their feedback system. For example, Opower used an RCT to show that recipients of their reports not only reduce energy usage but also become more engaged with utility energy efficiency programs (*e.g.,* by participating in more professional home energy audits, see Gunel 2012). We return to the value of RCTs in evaluating proenvironmental behavior change in the Discussion section.

Nest Smart Thermostat

The US government estimates that the average single-family home spends $2,200 annually on their energy bill, roughly half of which is under control of the thermostat (EnergyStar 2009). The Nest smart thermostat attempts to transform how householders control and manage home heating and cooling. It's marketed to save homeowners 20-30% on their utility bills (Nest 2013). Unlike many other examples in this chapter, Nest does not just provide feedback and rewards *for* behavior, it is designed to *learn* behavior and respond accordingly. To do so, it combines three data sources: (i) built-in motion and temperature sensors; (ii) local weather data (current and predicted, pulled from the Internet); (iii) and observations about the home occupant. From these sources, Nest automatically programs itself in “about a week” creating a personalized heating and cooling schedule for each household. Users can also set the temperature manually either via the device itself or remotely via the Internet. Yoky Matsuoka, Nest’s VP of Technology, recently stated that 98.6% of households have an automatic schedule set and of these households, the average energy savings is 19.5% with a maximum of 36.1% (Matsuoka 2012). Unlike Opower, however, Nest has not yet worked with independent researchers to verify their claimed customer energy savings.

Figure 4: The Nest (left) smart thermostat and (right) iPhone application. Nest uses virtual rewards in the form of iconic *Leafs* to incentivize energy-efficient home heating and cooling behaviors.

Nest’s persuasive design and use of gamification comes in a few forms. First, unlike most programmable thermostats (Peffer et al. 2011), Nest is aesthetically pleasing, easy to use and engaging. It lights up when you approach and illuminates in red or blue colors depending on whether the home is heating or cooling. Second, homeowners are awarded virtual *Leafs* for setting temperatures to energy-efficient levels. The Leaf mechanism was added to encourage user control over temperature adjustment after pilot testing found that some users responded negatively to automatic adjustments that were too aggressive[8] (Levy 2011). According to Matsuoka, this gamified Leaf mechanism appears to impact behavior: a majority of “Nesters” use the Leaf to guide temperature selection and 92% check for a Leaf at least once a week (Matsuoka 2012). Third, Nest recently started emailing *Nest Energy Reports* to customers, similar to Opower’s approach. These reports apply behavioral science and gamification principles through, for example, “kudos” badges for achieving a particular energy efficient behavior (rewards), historical self-comparison of performance (progress), a count of Leafs earned that month and

[8] This is not a new problem. Researchers in HCI and ubiquitous computing have long discussed tradeoffs of home automation and occupant agency, even for systems focused specifically on automating home HVAC control (Intille 2002)

in comparison to other users (social norms), and a mechanism to share the report over social media such as Facebook (social proofs).

Eco-feedback Beyond Single Family Residences

While the above two examples focused on motivating energy-efficient behaviors in single family homes, others have explored this topic in shared residences (e.g., at universities) and in businesses. As Pierce, Odom, and Blevis (2008) articulate, such contexts are unique because the occupants themselves have little control over energy usage while third parties (*e.g.,* building managers or owners) have a high level of control. In addition, these occupants typically receive little feedback about resource consumption and do not have the same incentives to conserve. Competitions, then, have been employed to raise awareness about environmental issues and to tap into a competitive spirit among dorm floors, dormitories, or campuses in a university residence context or among stores in a business setting. Starbucks, for example, has a pilot program to evaluate how employees respond to real-time energy feedback coupled with "friendly" competition. In a study across ten cafes, the top store saved 9% while the bottom increased usage by 2% over baseline (Russell 2012).

University residence hall (dorm) competitions have also become a popular mechanism for engaging students in energy issues (Hodge 2010) with typical competitions lasting two to six weeks and eco-feedback provided over the web and/or on shared public displays. These competitions generally result in lower resource consumption. For example, a 32% reduction in electricity usage use compared to baseline over two weeks at Oberlin College (Petersen et al. 2007), an 8% reduction over eight weeks at the University of Southern California (Sintov, Desario, and Prescott 2010), and a 10% reduction over six weeks at Dartmouth (Loeb et al. 2010). This latter study combined narrative with a virtual avatar (a polar bear) to represent energy efficiency: when electricity use was low, the polar bear was content and playful but as electricity use increased, the bear's happiness decreased and its livelihood became endangered (Figure 5). None of these studies report post-competition resource usage data so it is unclear if these reductions persisted. Moreover, the competitions are rather artificial in that they are advertised intensely and run for only a short period of time. We will discuss methodological limitations of many eco-feedback and green gamification studies in the Discussion section.

Figure 5: Loeb et al. (2010) used virtual animal characters that respond to real-world energy usage behavior in school buildings. In this case, when electricity use was low, the polar bear was happy but as use increased, the bear's health and happiness become endangered.

Explicitly Designed Home Resource Games

While the previous examples use some aspects of games (*e.g.,* competition, progress tracking, rewards) to help motivate proenvironmental behavior, a few academics and businesses are exploring the use of sensed behavior as *actual input* to video games. Although a few of these games have targeted water use (Ravandi, Mok, and Chignell 2009; Froehlich 2011), most have focused on energy (*e.g.,* Mahmud et al. 2007; Gustafsson, Bång, and Svahn 2009; Kimura and Nakajima 2011; Geelan et al. 2012; Reeves et al. 2012). As an example, Byron Reeves at Stanford along with his company *Serioisity, Inc.* created *Power House*, a social game that uses smart meter data to influence a player's in-game abilities and achievements (Reeves et al. 2012, see also Figure 6). Periodically, play is interrupted and players are offered an opportunity to learn more about resource consumption and challenge other players to competitions. The link between real world sustainability behaviors and virtual worlds is being investigated in industry as well. The green gamification startup, Zema Good Inc., partners with energy utilities to pay consumers *virtual* currency in online games (*e.g.,* Farmville) for verifiable energy savings in the real world. However, none of these gaming models—in academia or industry—have yet been shown to be effective. Both Zema Good Inc. and Power House are currently conducting private trials.

Figure 6: The Power House video game prototype uses smart meter data to automatically influence a player's in-game abilities and provide virtual rewards and achievements (Reeves et al. 2012).

Transportation

In 2003, the US transportation sector accounted for approximately 27% of total US greenhouse gas (GHG) emissions, an increase from 24.8% in 1990 (EPA 2006) Although airplanes are often considered significant CO_2 contributors, roughly 81% of all transportation related-GHG emissions in the US comes from *on-road vehicles* including passenger cars, sport-utility vehicles, motorcycles, and heavy trucks and buses[9]. Light-duty vehicles, which are used primarily for personal transport, account for 62% of overall

[9] The difference is scale. There are far more road vehicles and vehicle-based trips than there are airplanes and flights. With that said, a medium sized car produces roughly 3.5 tons of CO_2 emissions a year (based on 9,608 driving miles), which is approximately the same amount produced *per passenger* on a round-trip flight between Chicago and Frankfurt (Rosenthal 2013). Also, air travel volume is projected to rise significantly in the near future.

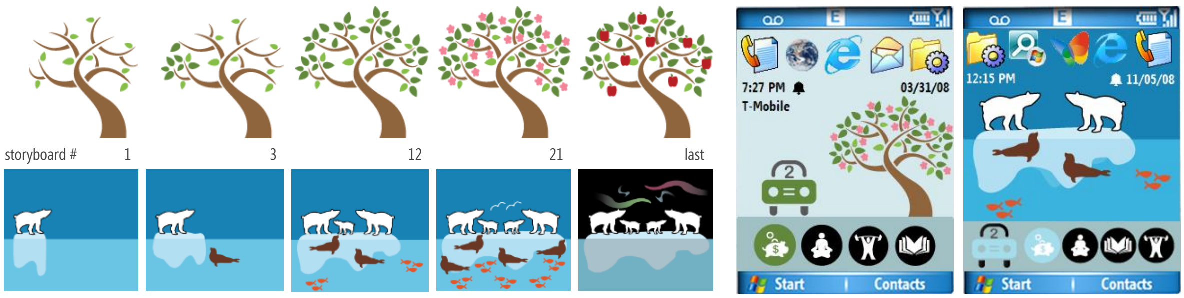

Figure 7: (a) The tree and polar bear UbiGreen designs. (b) An example screenshot on the mobile phone—note how the visualization fits unobtrusively in the background of phone (as "live" wallpaper). For both screenshots, the current activity is carpooling indicated by a car icon with the "2" in the windshield. Since carpooling saves money, the piggy-bank icon is also highlighted in the secondary value icon bar.

transportation GHG emissions. While technological improvements continue to increase average fuel efficiency in vehicles, these gains are offset by increases in the total number of miles driven. Since 1980, the number of miles Americans drive has grown three times faster than the US population (Ewing et al. 2007). Given the size of the transportation sector's CO_2 footprint and the amount coming from light-duty vehicles, in this section I explore how eco-feedback technology and gamification have been used to promote and encourage environmentally sustainable transit choices (*e.g.,* riding your bike to work *vs.* driving your car). For those times when driving is unavoidable, I also survey techniques for motivating economical/ecological driving behavior—so called eco-driving.

Motivating and "Gamifying" Green Transportation Decisions

Given the growing prevalence of mobile phones with sensing capabilities, one compelling opportunity to impact human behavior is to offer immediate feedback about how currently sensed or predicted behaviors affect the environment. In 2008, my colleagues and I designed and evaluated a mobile phone-based prototype called UbiGreen that sensed and fed back information about the user's "green" transportation behaviors through abstract, ambient visualizations. Transit activities were sensed through a combination of self-report and automatic inference based on cell tower signals and a multimodal sensor platform worn on the waist (the MSP, see Choudhury et al. 2008). Small graphical rewards were earned by taking "green" transportation such as riding the bus or train, walking, biking, or carpooling. Rather than require the user to launch an application to see the feedback visualization, UbiGreen ran constantly in the background of the device updating the phone's wallpaper as new trips were sensed—thus, the feedback was nearly omni-present and readily available anytime the user picked up their device.

We created two different visual designs for UbiGreen (Figure 7). Partly based on findings from social psychology that cognitive representations of different concepts become linked if those concepts are repeatedly encountered together (Higgins, 1996), we presented a representation of eco-friendly transportation along with other goals (e.g., saving money, getting exercise) depending on the sensed transit mode (row of icons in Figure 7b). We were also influenced by research in environmental psychology that showed how caring for animals helps humans connect with nature (Myers and Saunders, 2002). In one design, a tree grows based on green transit activity. At the start of each week, the tree is bare then leaves, blossoms, and eventually apples appear as green transit events are sensed.

In the other design, an arctic ecosystem evolves with green transit. The scene begins with a polar bear on an iceberg; as green trips are taken, the iceberg grows and other animals are added (*e.g.,* seals, seagulls, fish, and other polar bars) to portray a more thriving ecosystem. Both designs follow a linear sequence of images, starting with an initial screen at the beginning of the week and ending with a final visual "reward screen," which is reached by taking green transit. Although UbiGreen includes game-like mechanics—*e.g.,* the use of narrative, tracking progress, rewards, and stages—we did not explicitly conceive of the system as a game in our design meetings. Instead, we were inspired by the behavioral science literature related to feedback (Darby 2006), goals (Locke and Latham 2002), and self-monitoring (*e.g.,* McCann and Bovbjerg 2009, 222) as well as the aforementioned social and environmental psychology research.

We conducted a three-week qualitative pilot study of UbiGreen with thirteen participants to assess user reactions to the visual designs and the ways in which UbiGreen stimulated reflection and awareness about green transit. We found that using the phone's wallpaper for the feedback visualization successfully stimulated awareness about a user's transportation activities—one participant said "[the information] is omnipresent." Most relevant to the theme of gamification, users enjoyed the *unfolding narrative* of the image sequences, which provoked anticipation and curiosity as green trips were taken; however, this interest waned over time. Some users suggested being able to download new stories or the use of non-linear narratives to sustain engagement—it is unclear if this would be sufficient to actually change transportation behaviors.

Although we did not describe UbiGreen as a game to our participants, in interviews and in our freeform post-study survey data, participants used game-like metaphors when describing the prototype. For example, participants mentioned that engaging in green transit behaviors earned "points" and making it to the last screen was the "final level." One participant even complained that when a trip hadn't been automatically recorded that he was "being cheated out of points." Because so many participants conceptualized UbiGreen as a game, they considered opportunities to "cheat" the system problematic. For example, "I don't like incentives for getting points artificially by taking unnecessary trips… like trying to beat your own score by taking two more trips just to earn points." (Parcipant11). By virtue of UbiGreen's "reward structure"—where participants earned a new icon for each sensed *green* trip—the application could actually encourage people to take more trips simply to earn more points (some green trips could lead to more emissions than no trip at all). Future designs that incorporate a more overt gaming model could mitigate these effects by rewarding "more points" for zero-carbon trips such as bicycling and walking and/or by tracking and encouraging progress from week-to-week.

Shared Bicycling

While UbiGreen focused on exploring how activity inference and mobile phone visualizations could increase a person's awareness about their transportation habits, this subsection explores how persuasive tactics and gamification have been applied to a rapidly growing area of sustainable urban transit: bikeshare. A bicycle sharing system, or bikeshare, is a transit service where bicycles are shared among riders who do not own them, usually for a small fee. Advocates promote bikeshare as a convenient, eco-friendly, and low-cost form of public transportation that simultaneously reducing urban traffic congestion, noise, and air pollution. Although shared bicycling systems date back to the 1960s, the recent emergence of low-cost digital urban infrastructure has allowed for vastly different operating models (for an in-depth history, see DeMaio 2009). The first contemporary bikeshare system began in Lyon, France in 2005 (*Velo'v)* and has since spread to over 130 cities worldwide on six continents including Paris (Vélib'), Montreal (Bixi), and London (Barclays Cycle Hire) (Meddin and DeMaio 2013). While it is difficult to ascertain the net savings of bikeshare programs on carbon emissions, preliminary research suggests the programs offer a benefit despite the need for electronic bikeshare stations and other support infrastructure. In Paris alone, for example, an average of 110,000 Vélib' trips are made daily and the number of cyclists in the city have nearly doubled in the last five years (while car-to-bike accidents have actually decreased) (Simons 2012). Preliminary findings also suggests that bike-sharing is displacing between 8-16% of vehicle trips (McKenzie-Mohr 2011, 123).

With modern bikeshare systems, geographically distributed bicycle docking stations are controlled by computer kiosks linked to a backend server where bikeshare users can “check out” or “check in” bicycles using a membership identifier (*e.g.,* RFID dongle, membership card) or credit card payment. These transactions create digital records of usage behaviors, which have been used by researchers to analyze and predict city mobility patterns (Froehlich, Neumann, and Oliver 2009) as well as by operators and application developers for eco-feedback and gamification applications. For example, to help promote bikeshare usage, Montreal’s Bixi system publishes a leaderboard of the top riders in the city (the top rider in 2011 logged 1265 trips). Washington DC’s Capital Bikeshare (CaBi), currently the largest bikeshare system in the US[10], provides a “quantified-self” style webpage for members to track distances, calories burned, and CO2 emissions saved for each ride. It is unclear, however, what effect—if any—such systems have had on promoting adoption and usage.

Occasionally, system operators will run short-term contests to create publicity and incentivize particular usage patterns. CaBi’s *Winter Weather Warrior Contest*, for example, was an attempt to combat expected drops in usage during the system’s first winter in Washington DC. The contest included real prizes (*e.g.,* free memberships, gift cards) along with titles such as “Most Saddle Time,” “Longest Haul,” and “Perfect Attendance.” A rider could earn double points for riding in particularly bad weather—below freezing temperatures, in snow or cold rain. During the two-month contest, rides increased by 67% (Capitalbikeshare.com 2011) However, as is often the case with incentivization structures, many riders appeared to “game the system.” One rider averaged an astounding 13 trips per day. Another, the overall winner, took advantage of a “double points” day in the final week and earned 204 points by riding between all 104 active stations[11] (Jamieson 2011). Thus, while the Winter Weather Warrior Contest may have been useful to CaBi for generating positive publicity, it was likely not as successful as the increase in rides implies. This story also reflects the difficulty in setting up an incentive structure to

[10] New York’s bikeshare program, Citi Bike, will open in May of 2013 with 5,500 bicycles and 300 stations and quickly grow to 10,000 bicycles and 600 stations (see http://citibikenyc.com/]).
[11] He should have earned 208 but one ride was shorter than five minutes and the other was missed due to an electronic malfunction.

encourage particular behaviors. By introducing behavior-based rewards, there is a good chance that someone will try to "game" the game[12].

Perhaps the most difficult operational challenge for Bikeshare operators is load balancing; that is, ensuring that bikes are adequately spread across stations. Uneven distribution of bikes arises due to commuting directions, major events in the city, or human biases (*e.g.,* a preference for downhill rides). To counter this problem, cities use trucks to manually move bicycles between stations, which is costly, creates CO_2 emissions, and increases traffic congestion (DeMaio 2009). Some bikeshare programs have thus introduced persuasive tactics to encourage more efficient bike movement across stations. As one example, the Paris bikeshare system Vélib' offers a "bonus" 15-minute ride time credit for users who return a bicycle to one of ~100 designated uphill stations. According to DeMaio (2009), the program is a success and has resulted in increased use of these stations.

The future of bikeshare will likely involve mobile phone-based tools that will help users predict station capacities so that they can plan routes accordingly as well as persuasive systems to help make bikeshare more self-sustaining (*e.g.,* by incentivizing load-balancing bike movements).

Eco-Driving

While the tools above are useful to inform and support greener transit decisions, they are not particularly useful once a person has already decided to drive. Interestingly, behavior can play a key role here as well. Research has consistently found that fuel economy for a given vehicle can vary by 10-24% simply due to differences in driver behavior (Greene 1986; Ford 2008a; Gonder, Earleywine, and Sparks 2012). Economical driving behaviors, called eco-driving, include accelerating moderately, anticipating traffic flow and signals, driving at the speed limit, and eliminating excessive idling. According to recent estimates by Barkenbus (2010, 764), if one-third of all US drivers adopted eco-driving behaviors, 33 million metric tons of CO_2 would be saved per year (based on a per driver fuel reduction of 10%).

Although some vehicles manufactured in the early 1990s provided fuel efficiency information in their dashboards (*e.g.,* average miles-per-gallon, distance to an empty tank), it was not until the release of the Toyota Prius Hybrid that a mass-manufactured automobile provided instantaneous feedback on fuel efficiency through a visualization display. The original Prius, released in Japan in 1997 and worldwide in 2000, allowed drivers to compare their current fuel efficiency to a bar graph that displayed recent performance (six data points at five minute intervals) and an overall mileage average based on the trip odometer (Figure 8). This level of feedback was sufficient to not only improve driver fuel efficiency but, for some, to transform the driving experience into a game (*e.g.,* Bedard 2005; Fuller 2006). For example, in an early review of the Prius, Fuller notes that "constantly watching the mileage measurements on the Prius's little video screen is really a mobilized video game. It's NOT simply driving a car" (Fuller 2006, 1).

[12] Admittedly, when asked about the grand prizes, the winner stated "that's not really why I was doing it" (Jamieson 2011). So, it would appear that the idea of winning and, perhaps, the public leaderboard, was sufficient motivation rather than the prizes themselves.

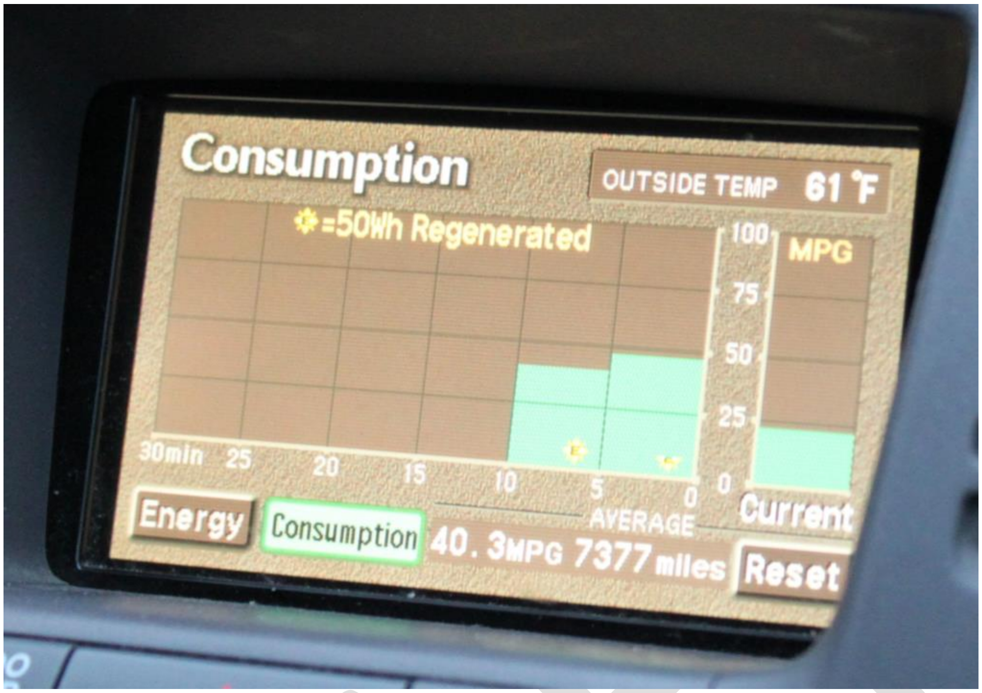

Figure 8: The original Toyota Prius eco-driving dashboard display, which includes instantaneous feedback on current fuel efficiency, a moving bar graph of average fuel efficiency in five minute intervals overall the last 30 minutes, the overall fuel efficiency since the trip odometer was last reset, and a "40Wh Regenerated" badge icon for regenerating energy via braking.

Qualitative research studies report similar findings (*e.g.,* Kurani et al. 2010; Stillwater and Kurani 2011). In a six-week study of 34 households provided with Toyota Priuses[13], researchers found that drivers attended to the instantaneous fuel economy feedback and reported changing their driving behavior as a result (Kurani et al. 2010). In addition, many drivers perceived the feedback display as a game and tried to maximize their fuel efficiency (*ibid,* 77). More than that though, the researchers stated that it "was not uncommon" for the feedback information to stimulate a competitive game between multiple household drivers. One driver remarked, "...yeah, I looked at that, and so my husband would have a contest, okay, let's see who had the best mileage" (*ibid*, 105). So, even though the Prius did not specifically offer features to support gaming or competitions (*e.g.,* by allowing the driver to login to identify themselves, by awarding badges/medals, or by specifically tracking points), these sorts of game-like phenomena arose nonetheless[14]. This seems to support my thesis that simple sensing and feedback systems even if not explicitly designed with gamification, may provoke gaming responses.

[13] Note: these were 2007 and 2008 model Toyota Priuses but modified to be plug-in electric hybrids. However, the researchers did not change the dashboard visualizations (they used "stock" versions). The feedback interface in the 2007/2008 Prius models was largely unchanged from the original Prius.

[14] My sister and her husband purchased a 1st generation Toyota Prius in 2003 and a similar competition emerged between them. Although they still have the car (with 185,000+ miles), my sister reports that, for her, the competition and intrigue subsided after a while: "I became busy and always in a hurry to get somewhere so I rarely paid attention to it [the fuel efficiency feedback]." My brother-in-law is adamant that he still takes notice and related a proud story of maximizing the mileage to 99mpg on a drive back from a friend's house soon after they purchased the car.

Interestingly, while the Prius interface was well received by consumers and car critics alike, from an eco-feedback perspective, it was relatively simple in that it offered no comparative or normative information about performance, no specific eco-driving instruction to drivers, and the gamification aspects were not, to my knowledge, intentionally designed. Each of these design points, however, has been explicitly addressed in newer eco-driving interfaces, which I briefly articulate below.

Eco-driving comparative information: Stillwater and Kurani (2011) found in interviews with Prius drivers that the raw fuel economy numbers were not sufficient and that many drivers wanted these contextualized by "normative or comparative information" (8). Drivers would ask, for example, about whether their fuel economy was good compared to others. As noted previously, normative comparisons allow people to situate their behavior in a broader context; to understand how they compare to others. This is now explicitly supported in some cars: both the Nissan Leaf's Carwings system and Fiat's eco:Ville allow drivers to compare their performance to others via online portals. As Makower (2012) states, by providing these comparisons "what had been solely a matter of personal virtue—driving more efficiently—has become a community activity" (4). Interestingly, for new electric/hybrid cars that do not support leaderboard or social comparison functionality, organic, user-led applications have emerged. Voltstats.net, for example, is a web application with no official affiliation to Chevrolet, which uses the OnStar Partner API to provide leaderboard and achievement tracking to interested Volt drivers. Although I am unaware of any studies empirically demonstrating the effect of these comparisons, prior eco-driving work has shown that social comparisons can increase driver efficiency at least in some contexts (*e.g.,* Runnion, Watson, and McWhorter 1978).

Eco-driving coaching: While the Prius's display could help a driver learn how to drive more efficiently, the system does not include any specific coaching or teaching. Dashboard instructional systems for eco-driving have been proposed and used from as early as the mid-1980s. For example, "shift indicators" recommend the optimum moment for a driver to up-shift or down-shift (Igarashi and Tomita 1983). Ford, Fiat, Nissan, and others now manufacture cars that provide some sort of eco-driving guidance. For example, Honda's Eco-Assist system, which was released in 2009, provides mileage feedback similar to the Prius but also contains a "feedback system that teaches you to drive more efficiently" (Honda 2013). The speedometer is flanked on each side by "coaching bars" that change from white to green depending on how efficiently you are driving.

Gamifying eco-driving: Finally, although the Prius is attributed by many with introducing game-like elements into the driving experience, there is no record of Toyota engineers knowingly incorporating game mechanics into their designs. In contrast, more recent eco-driving dashboards were specifically designed with games (and gamification) in mind. For example, Steve Bishop of IDEO, the design firm that co-designed the Ford SmartGauge interface, remarked: "when we observed hybrid drivers, we found they were going for high scores, a gaming behavior that has never existed in cars before. We designed to accommodate it" (O'Dell 2009). Both the Nissan Leaf and the Ford interface provide dashboard visualizations of growing leaves and vines that track and reward driver efficiency. Similar to UbiGreen, this abstract representation serves as both a visual indicator and a reward system for eco-friendly behaviors—the more efficient, the more lush and beautiful the leaves and vines (*e.g.,* see Ford 2008b).

Others have noted that this "virtual creature" makes eco-driving similar to playing a Tamagotchi-style[15] game where real-world actions affect the vitality of some organism (Makower 2012). In addition, the Nissan Carwings system allows efficient drivers to earn virtual trophies depending on their leaderboard placement compared to other drivers (

Figure 9: (left) The Nissan Leaf Carwings system ranks eco-driving performance across drivers in proximal geographic areas (as viewable in a web browser). Efficient drivers earn virtual rewards (trophies and medals). (right) The Ford Smart Gauge with Eco-Guide rewards eco-driving performance with an aesthetically pleasing vine that grows proportionally to fuel efficiency.

While the above points serve to illustrate a movement towards more explicitly designed persuasive and gamified eco-driving elements, there is a surprising lack of research quantitatively studying their actual effect on driving behavior. Most studies including (Jenness et al. 2009; Manser et al. 2010; Stillwater and Kurani 2011; Stillwater and Kurani 2012) are qualitative relying on user self-report to study changes in eco-driving attitude and behavior or are conducted in simulator environments rather than in the field (Van der Voort, Dougherty, and Van Maarseveen 2001). I could find only one large-scale quantitative investigation of a modern eco-driving interface's effect on driving behavior: a corporate report published by Fiat (2010) analyzing real driver data uploaded from their eco:Drive platform.

Using eco:Drive uploads from 42,000 drivers covering 9 million journeys, Fiat found that the average eco:Index for all drivers before receiving eco:Drive feedback was 59.2 out of 100 (Fiat 2010). Interestingly, however, this index varied considerably across different countries from 61.8 in the UK to 56.6 in Spain, which suggests, perhaps, differences in behavioral norms, weather patterns, and/or topography. Fiat analyzed a subset of this data—428,000 journeys made by 5,697 drivers in 5 countries and compared driver performance collected before and after receiving eco:Drive feedback. Over a 30 day period, they found that drivers reduced their fuel consumption by an average of 6% (the top 10% reduced fuel consumption by an average of 16%). Fiat also argues in their report that this study provides

[15] Tamagotchi is a handheld game in the form of a virtual pet simulation. The Tamagotchi creature goes through several stages of growth and develops differently depending on the care that the player provides—better care produces an adult creature that is smarter, happier, and demands less attention. As of 2010, over 76 million Tamagotchis have been sold worldwide (Bandai 2011).

"evidence that eco-driving behavior is maintained over time, with improvements growing steadily"; however, the study window was 30 days, which seems insufficient to make this claim.

Waste Disposal and Recycling

The EPA reports that in 2007 the US generated approximately 254 million tons of municipal solid waste—this is about 4.6 pounds per person per day, and an increase of almost two pounds daily per person since 1960 (EPA 2007). The average American manages to recycle about 1.5 pounds per day (~33%); however, the rest ends up in landfills (54%) or combusted for energy (13%) (*ibid*). Many of the materials typically found in household waste such as batteries, aerosols, oils, acids, and fluorescent tubes have hazardous environmental impacts. In addition, the entire lifecycle of waste, from the manufacturing and transportation of products and product packaging to the infrastructure required to deal with its disposal (*e.g.,* garbage trucks, landfills) has an enormous ecological consequence. Thus, a large number of studies dating back to the early 1970s have attempted to uncover *why* people recycle and *how* to promote recycling behavior.

Research has demonstrated that people who recycle are better informed than their non-recycling counterparts about which materials are recyclable, where these materials can be recycled, and the benefits that recycling has on the environment (Vining and Ebreo 1990). Prior work has found, for example, that the installation of signs describing what is and is not recyclable in close proximity to receptacles increases recycling behavior (Austin et al. 1993). In a more recent study, Duffy and Verges (2008) showed that the presence of specialized recycling container lids (*i.e.,* those that have holes shaped to reflect suitable contents) increased proper recycling activity Figure 10. Duffy and Verges posit that the specialized lids made it easier to determine what is and is not recyclable[16] and that the lids may have tacitly reminded individuals to comply with normative recycling behaviors (*e.g.,* you should separate your recyclables properly).

Figure 10: Duffy and Verges (2008) found that the presence of specialized recycling container lids increased the beverage-recycling rate by 34%, which, they argue suggests that perceptual affordances of the lids improves recycling compliance.

Feedback has also been shown to increase recycling activity and proper trash disposal. In 1980, Schnelle et al. studied the use of feedback on decreasing litter in particularly troublesome areas within the community. In their experiment, two independent observers manually counted the amount of litter in

[16] Related to Norman's notion of *perceived affordances* (Norman 2002). That is, those properties of an object that provide salient cues for use (*e.g.,* a vertical extruding door handle *affords* pulling, a pop-out bevel *affords* pushing). For a deeper discussion of the use of affordances in persuasive design, see (Lockton, Harrison, and Stanton 2008).

three target areas. Each day a descriptive statement about performance was published in the local newspaper along with a "Sad-O-Graph" or "Glad-O-Graph" depending on the amount of litter (Figure 11). During the three-week feedback period, litter was reduced in each area; however, post hoc counts taken one month later found a regression towards previous levels of litter. Others have found increases in recycling activity by using handwritten postcards to provide specific feedback to residences (Schultz 1999; De Young et al. 1995) or signs in public areas about recycling performance (Larson, Houlihan, and Goernert 1995; Aceti and McKenzie-Mohr 2003). In Schultz (1999), for example, 605 residents were studied for 17 weeks; two experimental groups received feedback on their household recycling behavior, one of which was contextualized by a social comparison to neighbors. Both interventions resulted in higher recycling participation and volume compared to baseline. Finally, in two early experiments, Geller and colleagues (Geller, Chaffee, and Ingram 1975; Witmer and Geller 1976) ran university contests where the dormitory that recycled the most received a small monetary reward. They found an increase in recycling behavior during the short, multi-week competition but a regression to baseline recycling levels once the competition ended. Interestingly, students whose rooms were closest to the recycling area had the highest levels of participation. Many subsequent studies in non-competition contexts have shown that recycling activity increases with the number and availability of recycling bins (Brothers, Krantz, and McClannahan 1994; O'Connor et al. 2010).

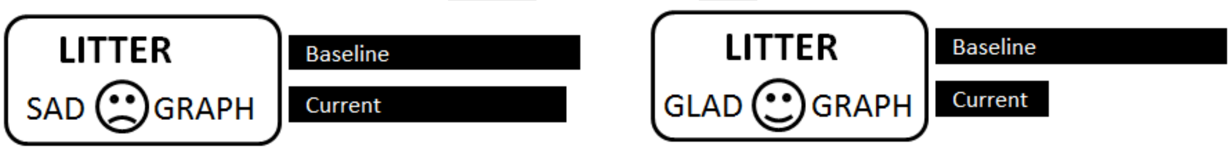

Figure 11: The "Sad-O-Graph" or "Glad-O-Graph" figures were published each day in a local newspaper depicting neighborhood litter amount (Schnelle et al. 1980). The motivational techniques used here include feedback, comparison, and injunctive messagiong.

Persuasive Recycling Bins

More recently, persuasive technology has been used to automatically track and promote environmentally responsible waste disposal behaviors. HCI researchers have explored a range of persuasive technology for waste, though behavior change evaluations have been limited. *Infotropism* is a live, organic eco-feedback system for waste (Holstius et al. 2004). Placed between pairs of trash and recycling containers, directional bursts of light are trigged by trash/recycling deposits, which gradually induces a living plant display to lean toward the more active container. A preliminary two-week study found negligible effects on recycling activity. Another prototype, *BinCam*, is a custom-designed trash bin that automatically captures pictures of discarded refuse and uploads them to Facebook (Thieme et al. 2012). The researchers also created *BinLeague* to motivate competition between BinCam households and reward virtual achievements for proenvironmental disposal behaviors. However, the studies were qualitative rather than quantitative in nature, exploring usability, notions of surveillance, user reactions to the system rather than behavior change. *Jetsam* is similar to BinCam in that it digitally augments a trashcan and photographs the internal contents; however, the researchers here had a more artistic, provocative focus. Their design was used in public garbage cans and the feedback was a projection system that visualized the bins' contents outward in a timelapse to cause passerbys to pause and reflect about trash in urban life (Paulos and Jenkins 2006). Finally, Volkswagen developed a series of viral marketing videos depicting the use of fun and persuasive technology to "change people's behavior for the better." Two designs featured in the videos were related to waste: *The World's Deepest Bin* (Volkswagen 2009a) and *Bottle Bank Arcade Machine* (Volkswagen 2009b). While neither bin design was studied in a rigorous, scientific manner, they were successful as viral marketing videos. At the time of writing, the two videos have accrued over 6.5 million views providing at least anecdotal evidence for interest in the use of fun to motivate routine activities.

Figure 12: (left) The Infotropism eco-feedback system controls the growth of a live plant to provide feedback about the more active container—trash or recycling (Holstius et al. 2004). (right) The Bottle Bank Arcade by Volkswagen was part of their "Fun Theory" series of viral videos to show how fun could be used to change people's thoughts and behaviors though the video shows only anecdotal evidence (Volkswagen 2009b)**.**

RecycleBank

The above studies point to the benefits of providing feedback on recycling performance and, potentially, the use of competitions, social comparisons, and fun to bolster interest and participation. However, they were limited in size, scope, and, often, practicality. Recyclebank, founded in 2004, is the first, and perhaps the most successful wide deployment of waste-related eco-feedback and gamification. Recyclebank tracks household recycling behavior by issuing special curbside recycling bins with a radio frequency identifier (RFID) tag that allows bins to be automatically identified and weighed when they are picked up by waste management trucks. Feedback about recycling volume over time is then provided to households via a website. Households also earn points for recycling, which can be redeemed for products and services from partnering companies (*e.g.*, WalMart, Ikea). Recyclebank reports that they are active in more than 300 communities across the US and the UK, serving more than 3 million customers who, on average, save more than $130 through their rewards program (Recyclebank 2011). More importantly, from an environmental perspective, the company reports increasing recycling activity by 14-155% in its partnering cities (Jones 2008; Recyclebank 2011). For many households, it is not just the promise of rewards that encourages recycling, but that, by virtue of the RFID weighing system, Recyclebank mandates that waste haulers shift to single stream recycling. Thus, homeowners can toss everything (*e.g.,* glass, plastic, paper) into a single bin rather than sorting it. Past research has shown that this single stream recycling increases participation and volume (Oskamp et al. 1996).

Recyclebank makes money via contracts with municipalities who save money when waste is diverted from landfills or incineration centers (Lui 2011). For example, during its first year in the Recyclebank program, the city of Hollywood, Florida saved nearly $500,000 in waste disposal fees while generating more than $250,000 in recycling revenue (NRDC 2011). Not all municipalities have been happy with

Recyclebank, however, often because of a failure to meet performance expectations—leading some cities to drop the program altogether (Thomas 2012; Davlin 2012). In an online survey investigating perceptions and usage of Recyclebank in Ann Arbor, the city found that only 17% of the 1012 respondents felt that the Recyclebank Rewards program encouraged them to recycle more and 63% reported not using any of their RecyleBank points primarily because none of the rewards were appealing (A2Gov 2011). The successes, however, appear to outnumber the failures. Fast Company magazine named Recyclebank one of the 50 most innovative companies of 2012 for making "eco-friendly behavior a big game" (FastCompany.com 2012) and the Wall Street Journal named Recyclebank the number one clean-tech company of 2011 (Debaise 2011). Recyclebank is also exploring how its business model may be adapted to other environmentally relevant areas such as e-waste recycling and energy reduction (Recyclebank 2011).

TerraCycle

Another commercial example is TerraCycle, which specializes in upcycling—that is, reusing waste materials that are otherwise difficult to recycle. For example, TerraCycle repurposes pre- and post-consumer waste packaging to make messenger bags, binders, and notebooks out of candy wrappers and Capri Sun drink pouches. In 2011, TerraCycle partnered with a game development company Guerillapps to build *Trash Tycoon*, a social network game similar to SimCity and Farmville. Played in Facebook, players collect litter in a virtual city covered in trash and then upcycle this waste into eco-friendly products (similar to TerraCycle). There is also crossover between the virtual and physical worlds; those persons who participate in TerraCycle's recycling programs can earn points in the game, which can be converted to special bonuses including in-game money and exclusive badges that highlight real-life achievements. Though Trash Tycoon may have been valuable in raising awareness about upcycling and teaching eco-friendly behaviors, the game itself—like many social media games—experienced rapid adoption followed by a rapid drop-off. The game shut down in July, 2012—roughly nine months after launch (Turner 2012). TerraCycle appears to be doing much better: its own points reward program focuses on donations to schools and charities. According to their website, they currently have over 20 million users in 20 countries and partnerships with Walmart and Whole Foods (TerraCycle 2013).

Discussion

While the above sections illustrate the use of persuasive technology and green gamification across a range of environmental domains, here we discuss contentious issues and open research questions. For the purposes of this discussion, persuasive technology encompasses green gamification. When I refer to one I refer to them both.

Ethics

Climate change and other environmental ills are ethical dilemmas just as they are technological, economic, political, behavioral, and social dilemmas. As such, any proper discussion of technology designed to inform or influence environmental behavior must also include a discussion of ethics. Fogg dedicates a full chapter to the topic in his book and even notes that some have criticized persuasive technology as "immoral" (Fogg 2003, 5). The ethics of persuasive systems becomes even more complicated in areas like public health and environmental sustainability where societal benefits must be weighed against potential encroachment on individual rights. Though ethically-oriented discussions, and debates are crucially important to persuasive technology—many of the criticisms have previously surfaced for other behavior-centric programs, which were not necessarily technologically mediated or controlled. For example, Guttman (1997) notes that health intervention research is typically justified because the intervention "aims to do good and to improve the welfare of the public" but that there are often implicit claims, hidden agendas, and ideologies that are under-expressed and explored. Moreover, the will to do good can be intoxicating, particularly when that good is necessary for business models and profit.

Is it ethical for a persuasive technology to deceive individual users for the greater "environmental good?" As noted above, previous work has shown that energy usage feedback systems that use social comparisons can cause a boomerang effect where energy efficient households actually increase their consumption (Schultz et al. 2007). Imagine, then, that designers decide to manipulate these comparisons such that every home is compared to more energy-efficient neighbors—a process which involves falsifying data. This new system proves incredibly effective and increases the overall energy efficiency in deployed homes by 15%, which has the very real benefit of eliminating the need for backup coal-powered electricity plants. Is this energy feedback design unethical? Where does one draw the line? Many of the new emerging business models around "green" gamification require that companies show net reductions using their systems (*e.g.,* Recyclebank and Opower). This creates an incentive to utilize persuasion (including gamification) in dubious ways to achieve results.

With respect to gamification specifically, McGonigal provides a rather simple ethical test: "if you use the power of games to give people an opportunity to do something thy want to do, then you're doing good. If you're using the power of games to get people to do something you want them to do, then you're doing evil" (McGonigal 2011). However, even these high level qualifications seem insufficient; for example, game players may want to spend a small amount of time playing World of Warcraft but end up unable to break themselves away from the addictive gameplay (which was largely designed to be that way). Could gamification, in some contexts, be similarly powerful?

Though space prevents us from discussing these ethical considerations in greater detail, they are clearly important and should be a center point of any persuasive technology or green gamification design process (see Davis 2012). I also point you to two other chapters in this book dedicated to the topic.

Personalization

Fogg (2003) argues that one of the most significant advantages of persuasive technology over previous persuasive forms is the ability to tailor messages and content towards individual needs, interests, personality characteristics, and contexts (38). Although an important vision, to design an effective tailoring system, one must anticipate how a diverse set of users will respond to the technology. This is not easy. It assumes the ability for a computational system to sense and infer human attributes that are difficult even for trained scientists (*e.g.,* clinical psychologists). Similarly, for games, Koster (2004) argues that "not only will a given game be unlikely to appeal to everyone, but that it is probably impossible for it to do so" (104). Put simply: people are diverse and situated in diverse contexts, it is unlikely that one set of motivational techniques and gamification strategies will appeal to everyone. How can we design for such diversity? Can persuasive systems adapt to particular learned user characteristics?

Some characteristics may be easier to sense than others—for example, a system can ask for a user to report their gender, which could inform the particular motivational tactics used to persuade behavior (though, of course, users could lie). In a review of gender differences in economic experiments, Croson and Gneezy (2009) found that women are, for example, more risk-averse, less favorable towards competition, and more sensitive to social cues than men (with some exceptions). A more relevant example pertaining to proenvironmental behavior comes from Costa and Kahn (2010) who found that households responded differently to the Opower Home Energy Reports depending on their political ideology[17]. In a randomized control trial of 35,000 treatment households and 49,000 control households, Costa and Kahn used purchased voter registration and marketing data to gather information on political party affiliation, level of education, and charitable contributions. They found that while Democratic households reduced their consumption by an average of 3%, Republican households actually increased their consumption by 1%. Preliminary research has also found that drivers vary in the ways in which they engage with and react to eco-feedback visualizations—*e.g.,* male *vs.* female drivers (Graving, Manser, and Becic 2010) and older *vs.* younger drivers (Höltl et al. 2012). In Höltl et al. (2012), the authors found that older drivers preferred eco-driving interfaces to provide instruction on when to shift gears and information on the current driving style's economical impact but that younger drivers were more interested in receiving adaptive navigation advice on how to save time (*e.g.,* based on current traffic conditions).

Understanding such behavioral differences is important in designing and tuning persuasive systems appropriately.

The Persuasiveness of Design

Earlier in this chapter, I argued that there is a spectrum between a design intended to serve informational purposes and one designed to serve persuasive purposes. Some have argued that all designs could, and perhaps should, be considered persuasive because all designs have the potential to influence thought and constrain or promote particular action (Redström 2006). Redström cites the American design theorist Richard Buchanan who argues that technology not only mediates rhetoric but *is* rhetoric. "By presenting an audience of potential users with a new product – whether simple as a plow or a new form of hybrid corn, or as complex as an electric light bulb or a computer – designers have directly influenced the actions of individuals and communities, changed attitudes and values, and shaped society in surprisingly fundamental ways. This is an avenue of persuasion not previously recognized" (Buchanan 1985, 6). Buchanan goes further to claim that "the designer, instead of simply making an object or a thing, is actually creating a persuasive argument that comes to life whenever a user considers or uses a product as a means to some end" (Buchanan 1985, 8). The interplay between a

[17] In the US, Environmental issues are politically polarizing with Democrats generally more favorable towards proenvironmental legislation compared to Republicans. For example, the 2012 National Environmental Scorecard of the League of Conservation Voters rated the Senate Democratic leadership a score of 98/100 while the Republican leadership received a score of 9/100 (LCV 2012).

designed use and the way that use is communicated to and perceived by the user has links to Norman's *perceived affordances* (*e.g.,* a vertical extruded door handle *affords* pulling, a beveled button affords pushing, see Norman 2002).

For Fogg, persuasive technology focuses on "the planned persuasive effects of computer technologies" and that "true persuasion—whether brought about by humans or computers—requires intentionality" (Fogg 2003, 16). Thus, the critical difference is the designer's explicit intent to persuade (endogenous intent) and not, necessarily, the end user's perception of or reaction to this persuasion (exogenous intent). As Fogg argues, "a rain storm may cause people to buy umbrellas, but the storm is not a persuasive event because it has no intentionality associated with it" (Fogg 1998, 226). Thus, although all designs may influence user behavior, Fogg constrains the definition of persuasive technology to that where the influence is desired and/or prescribed by the designer him/herself. Gamification is similarly designed with this intent—to persuade particular actions and/or stimulate specific emotional responses.

As Lockton *et al*. note (Lockton, Harrison, and Stanton 2010), designing with the intent to influence behavior recurs across a number of disciplines from urban planning (Katyal 2002) to human-computer interaction (Beale 2007). In this way, persuasive technology and gamification strategies can be more broadly categorized as a type of *persuasive design* (*e.g.,* see Lockton, Harrison, and Stanton 2008; Lockton, Harrison, and Stanton 2010), which is concerned with how design—technological or otherwise—shapes behavior. As Redström (2006) nicely articulates, "persuasive design is centered on the notion of argumentation as embedded in, and embodied by, artifacts, and the *dialogue* between designer and user regarding use" (116).

Credibility, Trust, and Expertise

Must we believe in and trust the information provided by an eco-feedback system in order for it to be effective? In short, yes, and a highly credible source is more effective at persuading than a low-credibility one (Pornpitakpan 2004). Fogg (2003) notes that credibility is a *perceived quality* that can differ across individuals and is primarily impacted by two key dimensions: the perceived *trustworthiness* and the perceived *expertise* of the source. Fogg argues that persuasive technology needs to be perceived highly across both dimensions in order to be effective.

Trustworthiness captures the perceived goodness, morality, and truthfulness of a source (Fogg 2003, 123). In my own research exploring in-home eco-feedback displays, my colleagues and I found that people generally prefer setting their own efficiency goals rather than having those goals set by a utility company precisely because they did not trust the utility's interests (Froehlich 2011; Froehlich et al. 2012). As a result, we suggested that persuasive systems provide a greater level of transparency and justification for their persuasive actions (*e.g.,* the eco-feedback display should provide rationale for recommending particular behaviors[18], setting specific goals).

[18] In a seminal paper, Herlocker, Konstan, and Riedl (2000) showed that recommender systems should *explain* their reasoning to increase user acceptance (*e.g.,* Amazon.com and Netflix both justify *why* they are recommending a product to you based on your previous purchasing or browsing behaviors).

As persuasive technology often relies on automated sensing to measure and track progress and reward achievements, invalid or erroneous sensor data can undermine trust in the system as a whole (*e.g.,* Figure 13). As one solution, Consolvo et al. (2008) recommend that persuasive technology systems should allow for end-user editing to correct sensing errors and provide information on missing data (p. 1805). Of course, an editing mechanism in the context of gamification could be abused to inflate performance and undercut the motivational system itself. This could be particularly problematic for companies that use gamification as a core part of their business model (*e.g.,* Recyclebank) where real awards with monetary value are used to incentivize behavior.

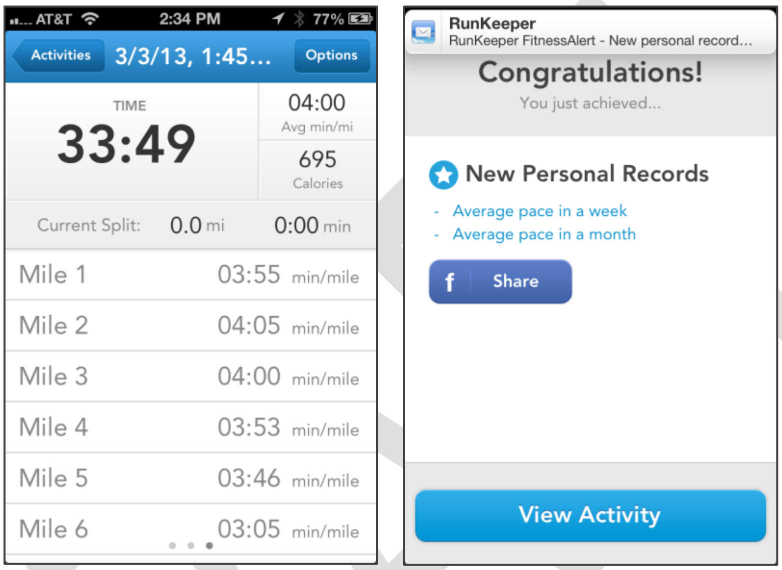

Figure 13: Runkeeper, a persuasive technology for promoting and supporting a fit lifestyle (*e.g.*, routine running behavior), incorrectly sensed one of my afternoon runs, which greatly exaggerated my pace (*e.g.*, average pace was 4:00 min/miles). This then led the application to award me two new personal records, which I will likely never break. Such errors can undermine trust, take the fun out of earning an award, and ultimately lead to user attrition.

Credibility is the perceived knowledge, skill, and experience of the source (Fogg 2003, 124). People use a variety of cues to evaluate expertise including titles (*e.g.,* "professor"), visual cues, documentation of accomplishments, and the source's history. With persuasive technology for sustainability (including green gamification), how can the user assess whether the designers are actually experts in sustainability? Brynjarsdóttir et al. (2012) have criticized persuasive sustainability work because it positions the designers "with the responsibility to decide what is or is not appropriate behavior… The designer seems to be *de facto* more knowledgeable about sustainability than the users of persuasive sustainability systems. But little evidence is provided that either the designer is actually an expert or that the user is uninformed" (953). Persuasive systems can mitigate this criticism by, again, improving transparency and providing drill-down information with links to source data when relevant.

Framing and Behavior Targets

In the same way that research has explored how environmental issues are communicated in public debates (*e.g.,* Macnaghten 1993) and by the mass media (*e.g.,* in TV, radio, billboards—see, *e.g.,* Sampei and Aoyagi-Usui 2009) so too must we consider how environmental problems are framed by persuasive technology. As Guttman notes, "an issue becomes a social problem only after it is defined as such by certain stakeholders and the way the problem is framed by them tends to reflect their values, priorities, or ideologies" (Guttman 1997, 98). When designers target a particular environmental problem, they are performing an act of prioritization and judgment. Similarly, their framing of the problem and solution has important implications for actually making a positive impact.

At one end of the spectrum, green gamification is cast as a solution for transforming "ambivalent consumers into eager eco-evangelists" (Aston 2012). The green gamification startup, Zema Good Inc. for example, partners with energy utilities to pay consumers *virtual* currency in online games (*e.g.,* Farmville) for verifiable energy savings in the real world[19]. Co-founder Eric Senunas has touted his company's approach by stating that "You will become [energy] efficient in spite of yourself because you want that farm cash" (Senunas 2012). Senunas' framing disregards proenvironmental attitudinal change completely in favor of the sheer motivational power of rewards on behavior (*i.e.,* you will act in proenvironmental ways even if your beliefs about the environment do not change). These quotes represent, perhaps, both the vast appeal of gamification and the willingness of many to imbue it with magic-like powers to "save the world" as well as, more critically speaking, rather cynical beliefs and shallow interpretations about what motivates human behavior (and the role of gamification therein).

Indeed, while gamification is cast as an eco-savior by some, at the other end of the spectrum, gamification is lambasted as "marketing bullsh*t" (Bogost 2011). This criticism is, perhaps, more apt in the green gamification context as companies attempt to leverage and nurture green profiles to improve brand perception. The quotes by Aston and Senunas are concerning not only because of the power they seem to bestow on gamification—a power that has not yet been earned nor shown to be longitudinally viable—but because of how easy they make attaining environmental sustainability. It's not even clear that the most important behaviors are being targeted.

For example, targeting one-time behaviors that provide a lasting impact (e.g., buying a low-flow showerhead) is different than targeting curtailment behaviors, which involve forming new routines to reduce environmental impact (e.g., taking shorter showers) (see Gardner and Stern, 2008). Additionally, while persuasive technology has focused on behaviors such as commuting and over-consumption, less direct behaviors have received a smaller amount of attention. One key challenge in environmental sustainability is population growth—Portland, Oregon, for instance, decreased its per-capita carbon footprint by nearly 4% between 1990 to 2008 but its population grew by 22%, offsetting the efficiency gains (Portland 2009). Perhaps, then, an additional behavioral focus should be family planning. As another potential target, Lehman and Geller (2004) argue that more interventions should encourage citizens to limit their stock investments to green companies, vote for proenvironmental candidates, and provide mechanisms to protest or boycott companies with a history of egregious pollution.

This narrow framing of environmental issues is not endemic to persuasive technology. Gardner and Stern (1996) question whether environmental psychologists have targeted the most important

[19] Experienced readers may see similarities between Zema Good Inc. and Kevan Davis' Chore Wars, a "chore management system" to help track and encourage housework by earning experience points, power-ups, and other rewards. See http://www.chorewars.com/ or Chapter 7 of Jane McGonigal's *Reality is Broken* (McGonigal 2011).

environmental problems or simply the most convenient ones. This suspicion applies equally to persuasive technology. Take recycling, for example, where Gardner and Stern (1996) point out that most behavioral solutions focus on the end of the waste stream—littering and recycling—rather than reducing consumption in the first place, which would lead to the greatest benefits. With this perspective, Recyclebank's approach, though successful in increasing recycling, seems misdirected—indeed, one could argue that their incentive structure actually increases consumption by providing rewards for overall volume or, at least, is setup to support and reinforce a culture of consumption.

Others have argued that corporations and organizations do "more to degrade the environment than individuals and households" (Stern 2000, 523) and thus deserve increased focus. Stern points out that motivating manufacturers to adopt "greener" production technologies and product designs, bankers and developers to consider environmental criteria in their decisions, and operational policies for plants and commercial buildings would likely have more impact than motivating individual proenvironmental action (Stern 2000, 410). Thus, how can we think more broadly about the use of persuasive technology and green gamification to influence organizational and governmental policies?

From Individual Action to Broad Societal Change

Persuasive technology has largely focused on individual behaviors (*e.g.,* eco-driving, energy use in the home), but there is doubt over whether this focus will lead to broad societal change (DiSalvo, Sengers, and Brynjarsdóttir 2010; Shove 2010; Brynjarsdóttir et al. 2012). John Thøgersen, for example, argues that campaigns for behavior change with small environmental impacts (*e.g.,* turn off the lights) only make sense if they lead to far-reaching impact in the long run (Thøgersen 2011). The problem is: how can we predict this impact at the outset? Even for more significant everyday behaviors (*e.g.,* biking to work vs. driving), how can we be certain that influencing a person to make proenvironmental choices will lead to larger-scale cultural shifts and create new norms of behavior? This transformation is often overlooked in persuasive technology research. As one alternative, Shove argues that we need to consider not just the individual behavior but the context within which that behavior takes place, including institutional, historical, and societal structures (Shove 2010, 1274). Similarly, in a recent UK government report (HouseOfLords 2011), a committee comprised of policymakers, scientists, economists and others recommended that "the most effective means of changing behavior at a population level is to use a range of policy tools, both regulatory and non-regulatory" (69)—that is, behavior-based approaches without policy and enforcement are unlikely to be successful. Thus, it is important to recognize that persuasive technology—whether incorporating gamification or not—is not a panacea and must be surrounded by social, structural, and regulatory policy to be effective.

Evaluation

Demonstrating the efficacy of persuasive technology for sustainability is, unquestionably, difficult. An ideal evaluation would measure not only the short-term impact of the technology, but also: (i) whether behavior change is sustained over time while the technology remains in place or if it is removed; and (ii) whether the change in behavior is enough to offset the full life-cycle environmental cost of the technology (including production, distribution, and disposal). Both analyses are critically important, yet behavior change with persuasive technology is rarely studied robustly in the field, especially over long periods and across populations (*e.g.,* see Froehlich, Findlater, and Landay 2010; Brynjarsdóttir et al. 2012). Moreover, I am unaware of any persuasive technology work that takes the full life-cycle cost of the technology into account. Complicating matters further is the theory of the *rebound effect* which postulates that energy savings enabled by increased efficiencies in technology are offset by increased use (*e.g.,* driving more after buying a fuel-efficient car)—see (Berkhout, Muskens, and Velthuijsen 2000; Gavankar and Geyer 2010). Thus, while persuasive technology may convince a person to reduce consumption in one area of their life, this may lead to unintended environmental consequences in other areas (indirect rebound effects).

Longitudinal studies are particularly important as they can explore the persistence of behavior change over time. That is, how durable are behaviors adopted in response to an extrinsic impetus such as persuasive technology? The gold standard for evaluating behavior change is a randomized controlled trial (RCT), but given the expense of long-term RCTs they are typically run by industry rather than in academic settings[20]. Companies like Google and Opower have recently made progress in this respect by implementing RCT infrastructures for home energy eco-feedback. For example, in an eight-month study of an energy usage web application, Houde et al. (2013) in partnership with Google found that the treatment group (*N*=752 households) decreased electricity consumption by 5.7% on average compared to a control group (*N*=313). Similar results were found by Mountain (2006) in a 2.5 year RCT of real-time energy feedback displays (*N=500* treatment, *N*=52 control). In exploring the effect of *removing* an intervention on proenvironmental behavior, Wu et al. (2012) and Ceniceros et al. (2012) showed that while households receiving Opower Home Energy Reports for two years saved 2.2% of electricity per month, these savings began decaying once the reports ceased (at a rate sufficient to wipeout gains within 20-24 months).

Given the limited number of longitudinal RCTs that have been conducted, we cannot draw strong conclusions about the effectiveness of particular design features. For example, the Google study above examined energy feedback over the web with a line-graph visualization and a simple in-home display, but a different type of visualization, visualization medium, use of motivational elements (*e.g.,* gamification), and/or the inclusion of a different population (e.g., non-Google engineers) may produce different results. As more companies invest in RCT infrastructures that support continuous A/B testing, our understanding of the impact of these and other factors will be greatly enhanced. However, most attention has been focused on residential energy feedback, and it is unclear what findings will translates to other environmental domains. In addition, RCTs need complementary qualitative investigations that can uncover otherwise difficult to observe characteristics such as user attitudes, self-reported behavioral changes, and perceptions of the persuasive technology itself.

Intrinsic vs. Extrinsic Motivation

Motivation—the reason or reasons for acting or behaving in a particular way—is one of the most central and perennial topics of inquiry in psychology (Ryan and Deci 2000). The issue of motivation, where it

[20] For more information on establishing proper study design for behavior-based efficiency programs with implications for the evaluation of persuasive technology for environmental sustainability, see (Sergici and Faruqui 2011).

comes from, how it works, and how it can be used is an important, often debated topic within persuasive technology, gamification, and environmental psychology communities. Typically, these debates center on the role of *intrinsic motivation,* which refers to doing something because it is inherently interesting or enjoyable, and *extrinsic motivation*, which refers to doing something for an outcome or reward (Ryan and Deci 2000). In short, intrinsic motivation comes from within the individual and extrinsic motivation comes from outside.

Researchers and game scholars argue that the choice and act of playing video games is intrinsically motivating. People play games because they enjoy them—they are fun, gratifying, and pleasurable (Koster 2004, 40; Deterding 2010; Ryan, Rigby, and Przybylski 2006). As Sawyer notes, "play is its own reward" (Sawyer 2010). Gamification, however, largely focuses on *extrinsic* motivation by adding a layer of externally driven incentives and rewards (*e.g.,* leaderboards, points, virtual trophies) on top of typically otherwise mundane, unenjoyable, or arduous tasks (*e.g.,* recycling or running). The problem is that extrinsically motivated behaviors are often more brittle, they tend to last only as long as the reward is provided (Deci, Koestner, and Ryan 1999), and the rewards themselves must increase in magnitude to trigger the same experience of pleasure and satisfaction (*i.e.,* hedonic adaptation, see Frederick and Loewenstein 1999). Perhaps even more concerning, the very presence of these external rewards can undermine intrinsic motivation (Kohn 1999). This motivational subversion is particularly problematic in the domain of environmental sustainability where, ideally, people would be *intrinsically* motivated to partake in proenvironmental actions long enough until they become routine. In this sense, green gamification does not seem like a promising solution; instead, it feels like a short-term fix.

De Young (1996) argues that it is not necessary to reward or coerce citizens through economic and social mechanisms to behave proenvironmentally but instead that approaches should highlight how a conservation-oriented lifestyle is intrinsically satisfying. De Young quotes Seligman *et al.* who suggest that "individuals can find satisfaction in many of the ways they practice conservation… they [become] interested in and challenged by the task of lowering their energy consumption, and [feel] satisfaction not previously present when they did so" (Seligman, Becker, and Darley 1981, 111). A key question moving forward, then, is how can persuasive technology and gamification be used to nurture feelings of intrinsic satisfaction (*e.g.,* by, perhaps, emphasizing the local and global importance of a person's proenvironmental action and the satisfaction one feels for this accomplishment)? Is this possible? If extrinsic motivation is the impetus for initial proenvironmental interest or behavior change, how can these extrinsic motivators become internalized?

Surveillance

Surveillance has long been a concern in persuasive technology (Fogg 2003, 47). Dourish argues that technologies designed to monitor and record actions, particularly in the realm of environmental sustainability, are a "natural path for various forms of surveillance and regulation" (Dourish 2010, 5). Certainly, even something as benign as a water meter can be used to ensure that householders comply with water-use restrictions (Halich and Stephenson 2009). And as behavioral sensing begins pervading nearly all aspects of our lives, there is greater opportunity for reappropriation and repurposement—some of which, undoubtedly, will be nefarious (*e.g.,* stalking) or used by government agencies or corporations to regulate and enforce particular behaviors. One problem, however, is that it is usually not clear from the onset how a sensing system could be reappropriated and for what purpose. As a rather simple example, consider the vehicle speedometer, which were first produced to satisfy curiosity about speed, but ultimately became a tool for regulation (Bud and Winter 1997, 567). With the movement towards ubiquitous sensing, similar legislation may emerge for activities that we could not currently imagine (*e.g.,* fines for not driving ecologically, mandates for recycling amounts).

The concern is not simply governmental regulation but also new ways in which corporations may learn about and exploit employee behavior or create new business models that reward a particular way of being. For example, Barkenbus (2010) discusses Progressive Insurance's *Snapshot* device, which, once installed, allows the company to charge a variable insurance rate based on an individual's safe driving habits. According to Progressive's website, Snapshot monitors driving behaviors not unlike the aforementioned eco-driving systems—"the better you drive, the more you can save"—up to 30% for the most conscientious drivers (Progressive 2013). Similar programs have emerged in Europe (GreenRoad 2009). How far away are we from similar insurance programs for our health based on measured activity levels or exposure to pollutants in the air? Clearly, this topic has serious implications for legislative policies around sensing and feedback and protecting our personal freedoms. It is yet unclear how new business models may emerge around utilizing our pervasively sensed activity data but they will emerge.

Persuasion, Coercion, and User Agency

For the purposes of persuasive technology, Fogg defines persuasion[21] as "an attempt to change attitudes or behaviors or both (without using coercion or deception)" (Fogg 2003, 15). This parenthetical is crucially important—and is partly what distinguishes *persuasion* from *propaganda* and other forms of influence. Fogg is adamant that persuasive technology should not coerce and should not deceive. While admitting that such techniques may effectively change behavior, Fogg argues that persuasion is different in that it "implies voluntary change—in behavior, attitude, or both." Others agree. In *Persuasion and Contemporary Culture*, Simons and Jones (2011) define persuasion as "human communication designed to influence the judgments and actions of others" (24) and specifically note that persuasion is different from other forms of influence such as coercion.

The line between coercion, deception, and persuasion is not, however, always clear. Fogg provides the example of a software registration dialog box that continuously and intermittently prompts a user for personal information but has no form of permanent dismissal or a pop-up advertisement with a dismissal timer over part of a webpage you are trying to read. As Fogg notes, "these and other 'persuasive' techniques may be viewed as subtly coercive and may have a cumulatively negative effect on users" (Fogg 2003, 21). Some systems actively deceive users—such as phishing attacks (*e.g.,* see Zhang, Hong, and Cranor 2007) or malware Trojan horse downloads—and are more easily identifiable as *deceptive* technology rather than persuasive technology (using Fogg's definition).

[21] Some scholars have been critical of Fogg's lack of treatment and discourse about persuasion in persuasive technology. As Ian Bogost states, "In the nearly three hundred pages of Persuasive Technology, Fogg devotes only a half-page sidebar to the subject of rhetoric, dismissively labeled as 'A Brief History of Persuasion Studies'" (Bogost 2010, 61).

For computer games and gamification approaches, there is a similarly muddled line between persuasion and coercion. Video games are explicitly designed to create and sustain player engagement and provide pleasurable experiences matched to our skill level. This optimal psychological mixture of goals, challenges, and continuous feedback that activate pleasure-centers in our brain can also, in some cases, be addicting. For addicted players, play is not a choice—it is a compulsive need. Thus, the very same elements that make them fun and pleasing can also be problematic. As McGonigal (2011) notes, "gamer addiction is a subject the industry takes seriously—it's a frequent topic at industry conferences and on game developer forums" (43). Is addiction relevant to the gamification context? Could game-design elements be used to drive real-life behaviors beyond the user's own control?

Another particularly controversial aspect of persuasive technologies is whether they reduce a user's agency and sense of self by prescribing particular ways of being—ways which are defined or, at least, constrained by the designers, not by the users (*e.g.,* Purpura et al. 2011). An alternative view is that persuasive technology empowers users by offering support, motivation, and encouragement towards a shared behavioral goal (a goal shared between the user and the designer). The degree to which either of these views holds depends on the context in which the technology is used (*e.g.,* is it adopted and used by free choice or mandated by a government, doctor, or employer) and how it is designed (*e.g.,* can the user self-set goals, configure motivational strategies, help define "success"). Regardless, designers must be aware that their particular interventions may not fit or benefit all people: *e.g.,* an application that rewards water-usage efficiency in the home may not adequately account for consumption based on medical or religious reasons (see Froehlich 2011, 137-141).

In my own experience working on persuasive technology, I have found a general distaste for the word "persuasive" because of its negative connotations (*e.g.,* sleazy car salesman). Others have criticized the phrase as well: Bogost suggests that a better, and perhaps more representative, word pair would be *manipulative technology* (Bogost 2010, 62). Although I find this criticism unfair—particularly because this view seems to imply that all persuasion is manipulative (it is not) and because Fogg is quite honest about his own ethical concerns with regards to persuasive technology (*e.g.,* see Fogg 2003)—it does suggest that "persuasive technology" is perhaps a , given the pushback on the term "persuasive technology," my colleagues[22] and I have considered alternatives that are less provocative. We recently settled on *technology-mediated behavior change applications*, which although still imperfect has the dual advantage of omitting the word "persuasive" and placing an emphasis on technology's role as a mediator, rather than, say, sole director, in the behavior change process.

Conclusion

We are at the precipice of a new era of computing where small sensors, sophisticated machine learning algorithms, and pervasive computation will allow for monitoring and tracking a breadth of human activity—all of which can be gamified. Some have cast this future with a dystopic twist where no action is performed without some superficial reward (Schell2013)—from brushing teeth to accomplishing daily

[22] Primarily Dr. Eric Hekler, a health behavior psychologist and professor in the School of Nutrition and Health at Arizona State University and Dr. Predrag Klasnja, an expert in health informatics and professor in the School of Information at the University of Michigan.

chores. My perspective, however, is more balanced. As a computer scientist, I believe that computational sensing will continue to abound and that these advances will enable new ways of thinking about and understanding human behavior as never before. As digital displays become even more pervasive—in jewelry, glasses, or even under our skin—there will be increased opportunity for sensing and feeding back a variety of signals from our physiological well-being to the environmental impact of our actions. However, rather than a source of disillusionment and harm, I see this as a source of empowerment, of previously unrecoverable knowledge that can be used as a basis for good, particularly with regards to personal health and environmental sustainability. To make a gaming analogy, we are at the Atari 2600 stage of persuasive technology and gamification—even the 8-bit NES is but in the distant future—there is much to learn, much to play with, and much to overcome. Though gamification as at the peak of its hype cycle, the ideas and principles it represents will live on in one form or another and, I think, will be a source of positive change.

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Bibliography

A2Gov. 2011. *City of Ann Arbor, Residential Recycling Fall 2011, Survey Results*. http://www.a2gov.org/government/publicservices/fieldoperations/solidwasteunit/Documents/Residential_Recycling_Survey_Results_Fall_Final_2011.pdf.

ACEEE. 2010. *State Energy Efficiency Resource Standard (EERS) Activity*. http://www.aceee.org/files/pdf/State EERS Summary Aug 2010.pdf.

Aceti, Jan, and Doug McKenzie-Mohr. 2003. *Using Feedback to Increase Drop-off Recycling Participation*. http://www.acetiassociates.com/pubs/doverreport.pdf.

Aitken, Campbell K., Thomas a. McMahon, Alexander J. Wearing, Brian L. Finlayson, K. Aitken Campbell, and Wearing Alexander J. 1994. "Residential Water Use: Predicting and Reducing Consumption." *Journal of Applied Social Psychology* 24 (2) (January): 136–158. doi:10.1111/j.1559-1816.1994.tb00562.x. http://www.blackwell-synergy.com/doi/abs/10.1111/j.1559-1816.1994.tb00562.x.

Alberini, Anna, and Massimo Filippini. 2011. "Response of Residential Electricity Demand to Price: The Effect of Measurement Error." *Energy Economics* 33 (5): 889–895. doi:10.1016/j.eneco.2011.03.009. http://www.sciencedirect.com/science/article/pii/S0140988311000776.

Allcott, H, and S Mullainathan. 2010. "Behavioral Science and Energy Policy." *Science* 327 (5970): 1204–1205.

Allcott, Hunt. 2011. "Social Norms and Energy Conservation." *Journal of Public Economics* 95 (9-10) (October): 1082–1095. doi:10.1016/j.jpubeco.2011.03.003. http://linkinghub.elsevier.com/retrieve/pii/S0047272711000478.

Aston, Adam. 2012. "Green Gamification Takes Root in the Big Apple." *GreenBiz*. http://www.adamaston.com/?p=847.

Austin, J, D B Hatfield, A C Grindle, and J S Bailey. 1993. "Increasing Recycling in Office Environments: The Effects of Specific, Informative Cues." *Journal of Applied Behavior Analysis* 26 (2) (January): 247–53. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1297743&tool=pmcentrez&rendertype=abstract.

Ayres, Ian, Sophie Raseman, and Alice Shih. 2009. "Evidence from Two Large Field Experiments That Peer Comparison Feedback Can Reduce Residential Energy Usage." In *5th Annual Conference on Empirical Legal Studies Paper*, 1–35. doi:http://dx.doi.org/10.2139/ssrn.1434950. http://www.nber.org/papers/w15386.pdf.

Bandai. 2011. *Tamagotchi iD L*. http://www.bandai.co.jp/press/images/3/60294.pdf.

Barkenbus, Jack N. 2010. "Eco-driving: An Overlooked Climate Change Initiative." *Energy Policy* 38 (2): 762–769. doi:10.1016/j.enpol.2009.10.021. http://www.sciencedirect.com/science/article/pii/S0301421509007484.

Beale, Russell. 2007. "Slanty Design." *Communications of the ACM* 50 (1) (January 1): 21. doi:10.1145/1188913.1188934. http://dl.acm.org/ft_gateway.cfm?id=1188934&type=html.

Bedard, Patrick. 2005. "Buying Pleasure: Will It Be a Hemi or a Hybrid." *Car and Driver*, December. http://www.caranddriver.com/columns/buying-pleasure-will-it-be-a-hemi-or-a-hybrid-feature.

Berkhout, P. H. G., J. C. Muskens, and J. W. Velthuijsen. 2000. "Defining the Rebound Effect." *Energy Policy* 28 (6-7): 425–432. http://www.sciencedirect.com/science/article/pii/S0301421500000227.

Bin, Shui, and Hadi Dowlatabadi. 2005. "Consumer Lifestyle Approach to US Energy Use and the Related CO2 Emissions." *Energy Policy* 33 (2) (January): 197–208. doi:10.1016/S0301-4215(03)00210-6. http://linkinghub.elsevier.com/retrieve/pii/S0301421503002106.

Bogost, Ian. 2010. *Persuasive Games: The Expressive Power of Videogames*. The MIT Press. http://www.amazon.com/Persuasive-Games-Expressive-Power-Videogames/dp/0262514885.

———. 2011. "Gamification Is Bullshit." *The Atlantic*. http://www.theatlantic.com/technology/archive/2011/08/gamification-is-bullshit/243338/.

Brewer, Garry D., and Paul C. Stern. 2005. *Decision Making for the Environment: Social and Behavioral Science Research Priorities*. Panel on Social and Behavioral Science Research Priorities for Environmental Decision Making, Committee on the Human Dimensions of Global Change, National Research Council.

Brothers, K J, Patricia J. Krantz, and Lynn E. McClannahan. 1994. "Office Paper Recycling: A Function of Container Proximity." *Journal of Applied Behavior Analysis* 27 (1) (January): 153–60. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1297784&tool=pmcentrez&rendertype=abstract.

Brynjarsdóttir, Hrönn, Maria Håkansson, James Pierce, Eric P S Baumer, Carl Disalvo, and Phoebe Sengers. 2012. "Sustainably Unpersuaded : How Persuasion Narrows Our Vision of Sustainability": 947–956.

Buchanan, Richard. 1985. "Declaration by Design: Rhetoric, Argument, and Demonstration in Design Practice." *Design Issues* 2 (1): pp. 4–22. http://www.jstor.org/stable/1511524.

Bud, Robert, and Deborah Winter, eds. 1997. *Instruments of Science: An Historical Encyclopedia (Garland Encyclopedias in the History of Science)*. Routledge. http://www.amazon.com/Instruments-Science-Historical-Encyclopedia-Encyclopedias/dp/0815315619.

Capitalbikeshare.com. 2011. “Capital Bikeshare Boasts Near Record Ridership in February.” http://www.capitalbikeshare.com/news/2011/03/10/capital-bikeshare-boasts-near-record-ridership-in-february.

Ceniceros, Bruce, May Wu, Pete Jacobs, and Patricia Thomspon. 2012. “New Insights for Home Energy Reports: Persistence, Targeting Effectiveness, and More.” In *Behavior, Energy, and Climate Change Conference (BECC)*. http://www.integralanalytics.com/ia/Portals/0/BECCSMUDHERImpactEvaluation.pdf.

Chatfield, Tom. 2010. “My TED Talk: 7 Ways Games Reward the Brain.” *Tomchatfield.net*. http://tomchatfield.net/2010/07/16/tom_chatfield_7_ways_games_reward_the_brain/.

Choudhury, Tanzeem, G Borriello, Sunny Consolvo, D Haehnel, B Harrison, Bruce Hemingway, Jeffrey Hightower, and Danny Wyatt. 2008. “The Mobile Sensing Platform: An Embedded System for Capturing and Recognizing Human Activities.” *Institute of Electrical and Electronics Engineers (IEEE) Pervasive Computing* 7 (2): 32–41.

Cialdini, Robert B. 2008. *Influence: Science and Practice (5th Edition)*. 5th ed. Pearson. http://www.amazon.com/Influence-Science-Practice-5th-Edition/dp/0205609996.

Cialdini, Robert B., Raymond R. Reno, and Carl a. Kallgren. 1990. “A Focus Theory of Normative Conduct: Recycling the Concept of Norms to Reduce Littering in Public Places.” *Journal of Personality and Social Psychology* 58 (6): 1015–1026. doi:10.1037/0022-3514.58.6.1015. http://doi.apa.org/getdoi.cfm?doi=10.1037/0022-3514.58.6.1015.

Consolvo, Sunny, David W. McDonald, Tammy Toscos, Mike Y. Chen, Jon Froehlich, Beverly Harrison, Predrag Klasnja, et al. 2008. “Activity Sensing in the Wild: a Field Trial of Ubifit Garden.” In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI ’08)*, 1797–1806. ACM. http://portal.acm.org/citation.cfm?id=1357335.

Cooney, Kevin, and Bill Provencher. 2011. *Evaluation Report: OPOWER SMUD Pilot Year2*. Boulder, CO. http://opower.com/uploads/library/file/6/opower_smud_yr2_eval_report_-_final-1.pdf.

Costa, Dora L, and Matthew E Kahn. 2010. “Energy Conservation ‘Nudges’ and Environmentalist Ideology: Evidence from a Randomized Residential Electricity Field Experiment.” *NBER Working Paper Series* Working Pa: 1–34. http://www.nber.org/papers/w15939.

Cousteau, Philippe, Ashok Kamal, Carrie Freeman, and Jeffrey Pank. 2012. “Gaming the Environment for Positive Change.” In *South by Southwest (SXSW) 2012*. Austin, Texas, USA. http://schedule.sxsw.com/2012/events/event_IAP100610.

Croson, Rachel, and Uri Gneezy. 2009. “Gender Differences in Preferences.” *Journal of Economic Literature* 47 (2): 448–474. doi:doi:10.1257/jel.47.2.448. http://www.ingentaconnect.com/content/aea/jel/2009/00000047/00000002/art00003.

Darby, Sarah. 2006. *The Effectiveness of Feedback on Energy Consumption: A Review for DEFRA of the Literature on Metering, Billing and Direct Displays*. *Environmental Change Institute, University of Oxford.* http://www.eci.ox.ac.uk/research/energy/downloads/smart-metering-report.pdf.

Davis, Janet. 2012. “Early Experiences with Participation in Persuasive Technology Design.” In *Proceedings of the 12th Participatory Design Conference: Research Papers - Volume 1*, 119–128. New York, NY, USA: ACM. doi:10.1145/2347635.2347653. http://doi.acm.org/10.1145/2347635.2347653.

Davlin, Melissa. 2012. “Council Ditches Recyclebank.” *Times-News*, August 14. http://magicvalley.com/news/local/council-ditches-recyclebank/article_78c18c0b-0db2-53e1-a0b8-58609336bcbe.html.

Debaise, Colleen. 2011. "The Top 10 Clean-Tech Companies." *The Wall Street Journal*, March 4. http://online.wsj.com/article/SB10001424052748703559604576176473635179098.html.

Deci, Edward L, Richard Koestner, and Richard M Ryan. 1999. "A Meta-analytic Review of Experiments Examining the Effects of Extrinsic Rewards on Intrinsic Motivation." *Psychological Bulletin* 125 (6): 627–668. doi:10.1037/0033-2909.125.6.627.

DeMaio, P. 2009. "Bike-sharing: History, Impacts, Models of Provision, and Future." *Journal of Public Transportation* 14 (4): 41–56. http://www.worldtransitresearch.info/research/3211/.

Deterding, Sebastian. 2010. "Pawned. Gamification and Its Discontents." In *Playful*, 62. London, UK. http://codingconduct.cc/Pawned.

Deterding, Sebastian, Dan Dixon, Rilla Khaled, and Lennart Nacke. 2011. "From Game Design Elements to Gamefulness: Defining 'Gamification'." In *Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek '11*, 9. New York, New York, USA: ACM Press. doi:10.1145/2181037.2181040. http://dl.acm.org/citation.cfm?id=2181037.2181040.

DeWitt, Katie. 2013. "Opower Achieves Its Second Terawatt-hour of Energy Savings." *OPower Blog*. http://blog.opower.com/2013/01/opower-achieves-its-second-terawatt-hour-of-energy-savings/.

Dietz, Thomas, Gerald T Gardner, Jonathan Gilligan, Paul C Stern, and Michael P Vandenbergh. 2009. "Household Actions Can Provide a Behavioral Wedge to Rapidly Reduce U.S. Carbon Emissions." *Proceedings of the National Academy of Sciences*. doi:10.1073/pnas.0908738106. http://www.pnas.org/content/early/2009/10/23/0908738106.abstract.

DiSalvo, Carl, Phoebe Sengers, and Hrönn Brynjarsdóttir. 2010. "Mapping the Landscape of Sustainable HCI." *Proceedings of the 28th International Conference on Human Factors in Computing Systems - CHI '10* 30332: 1975. doi:10.1145/1753326.1753625. http://portal.acm.org/citation.cfm?doid=1753326.1753625.

Dourish, Paul. 2010. "HCI and Environmental Sustainability: The Politics of Design and the Design of Politics." In *Proceedings of the 8th ACM Conference on Designing Interactive Systems*, 1–10. New York, NY, USA: ACM. doi:10.1145/1858171.1858173. http://doi.acm.org/10.1145/1858171.1858173.

Duffy, S., and M. Verges. 2008. "It Matters a Hole Lot: Perceptual Affordances of Waste Containers Influence Recycling Compliance." *Environment and Behavior* 41 (5) (October 14): 741–749. doi:10.1177/0013916508323737. http://eab.sagepub.com/cgi/doi/10.1177/0013916508323737.

Egan, Christine. 1999. "Graphical Displays and Comparative Energy Information: What Do People Understand and Prefer?" In *European Council for an Energy-Efficient Economy (ECEEE) 1999 Summer Study*, 2–12. http://www.eceee.org/conference_proceedings/eceee/1999/Panel_2/p2_12/. .

Ehrhardt-Martinez, Karen, Kat A. Donnelly, and John A. "Skip" Laitner. 2010. *Advanced Metering Initiatives and Residential Feedback Programs: a Meta-review for Household Electricity-saving Opportunities*.

EnergyStar. 2009. "Where Does My Money Go? Annual Energy Bill for a Typical Single Family House Is Approximately $2,200." http://www.energystar.gov/index.cfm?c=products.pr_pie.

EPA. 2006. *Greenhouse Gas Emissions from the U.S. Transportation Sector 1990–2003*. *United States Environmental Protection Agency, Office of Transportation and Air Quality (6401A)*. http://www.epa.gov/otaq/climate/420r06003.pdf.

———. 2007. *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2007*. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw07-fs.pdf.

Ewing, Reid, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen. 2007. *Growing Cooler: The Evidence on Urban Development and Climate Change*. Washington, D.C.: The Urban Land Institute.

FastCompany.com. 2012. "The World's 50 Most Innovative Companies." *Fast Company*. http://www.fastcompany.com/most-innovative-companies/2012/full-list.

Fiat. 2010. *Eco-Driving Uncovered: The Benefits and Challenges of ECo-Driving, Based on the First Study Using Real Journey Data*. *Fiat Corporate Report*. http://www.fiat.co.uk/uploadedFiles/Fiatcouk/Stand_Alone_Sites/EcoDrive2010/ECO-DRIVING_UNCOVERED_full_report_2010_UK.pdf.

Fischer, Corinna. 2008. "Feedback on Household Electricity Consumption: a Tool for Saving Energy?" *Energy Efficiency* 1 (1) (May 6): 79–104. doi:10.1007/s12053-008-9009-7. http://www.springerlink.com/index/10.1007/s12053-008-9009-7.

Fogg, BJ. 1997a. "Charismatic Computers: Creating More Likable and Persuasive Interactive Technologies by Leveraging Principles from Social Psychology." *Stanford University, PhD Dissertation*. Stanford University. http://dl.acm.org/citation.cfm?id=287026.

———. 1997b. "Captology: The Study of Computers as Persuasive Technologies." In *CHI '97 Extended Abstracts on Human Factors in Computing Systems Looking to the Future - CHI '97*, 129. New York, New York, USA: ACM Press. doi:10.1145/1120212.1120301. http://dl.acm.org/citation.cfm?id=1120212.1120301.

———. 1998. "Persuasive Computers: Perspectives and Research Directions." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '98)*, 225–232. New York, New York, USA: ACM Press. doi:10.1145/274644.274677. http://dl.acm.org/citation.cfm?id=274644.274677.

———. 2003. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann. http://www.amazon.com/Persuasive-Technology-Computers-Interactive-Technologies/dp/1558606432.

Fogg, BJ, and Clifford Nass. 1997. "How Users Reciprocate to Computers: An Experiment That Demonstrates Behavior Change." In *CHI '97 Extended Abstracts on Human Factors in Computing Systems*, 331–332. New York, NY, USA: ACM. doi:10.1145/1120212.1120419. http://doi.acm.org/10.1145/1120212.1120419.

Ford. 2008a. *Ford Tests Show Eco-Driving Can Improve Fuel Economy by An Average of 24 Percent*. http://media.ford.com/article_display.cfm?article_id=28948.

———. 2008b. *Ford's SmartGauge With Ecoguide Coaches Drivers To Maximize Fuel Efficiency On New Fusion Hybrid*. Dearborn, Michigan. http://media.ford.com/article_display.cfm?article_id=29300.

Frederick, Shane, and George Loewenstein. 1999. "Hedonic Adaptation." In *Well-being: The Foundations of Hedonic Psychology*, ed. Daniel Kahneman, Ed Diener, and Norbert Schwarz, 302–329. New York, NY, US: Russell Sage Foundation.

Froehlich, Jon. 2011. "Sensing and Feedback of Everyday Activities to Promote Environmental Behaviors." *University of Washington, PhD Dissertation*. University of Washington. http://gradworks.umi.com/35/01/3501869.html.

Froehlich, Jon, Tawanna Dillahunt, Predrag Klasnja, Jennifer Mankoff, Sunny Consolvo, Beverly Harrison, and James A. Landay. 2009. "UbiGreen: Investigating a Mobile Tool for Tracking and Supporting

Green Transportation Habits." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '09)*, 9:1043–1052. ACM. http://portal.acm.org/citation.cfm?id=1518861.

Froehlich, Jon, Leah Findlater, and James Landay. 2010. "The Design of Eco-feedback Technology." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*, 1999–2008. New York, New York, USA: ACM. doi:10.1145/1753326.1753629. http://portal.acm.org/citation.cfm?doid=1753326.1753629.

Froehlich, Jon, Leah Findlater, Marilyn Ostergren, Solai Ramanathan, Josh Peterson, Inness Wragg, Eric Larson, et al. 2012. "The Design and Evaluation of Prototype Eco-feedback Displays for Fixture-level Water Usage Data." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*, 2367–2376. doi:10.1145/2208276.2208397. http://dl.acm.org/citation.cfm?id=2208276.2208397.

Froehlich, Jon, Joachim Neumann, and Nuria Oliver. 2009. "Sensing and Predicting the Pulse of the City Through Shared Bicycling." In *Twenty-First International Joint Conference on Artificial Intelligence (IJCAI-09)*, 1420–1426. http://www.aaai.org/ocs/index.php/IJCAI/IJCAI-09/paper/download/578/910.

Fuller, Harry. 2006. "Raise Your Prius Gaming Score." *CNET News*. http://news.cnet.com/8301-10784_3-6108871-7.html.

Gardner, Gerald T., and Paul C. Stern. 2002. *Environmental Problems and Human Behavior*. Boston Pearson Custom. http://www.amazon.com/Environmental-Problems-Behavior-Gerald-Gardner/dp/0536686335.

Gavankar, Sheetal, and Roland Geyer. 2010. *The Rebound Effect: State of the Debate and Implications for Energy Efficiency Research*. http://iee.ucsb.edu/files/pdf/Rebound Report for IEE-UCSB_0.pdf.

Geelan, Daphne, David Keyson, Stella Boess, and Han Brezet. 2012. "Exploring the Use of a Game to Stimulate Energy Saving in Households." *Journal of Design Research* 10 (1/2): 102–120. doi:10.1504/JDR.2012.046096.

Geller, E. Scott, Jeanne L. Chaffee, and Richard E. Ingram. 1975. "Promoting Paper-recycling on a University Campus." *Journal of Environmental Systems* 5 (1): 39–57. doi:10.2190/E2LM-JNTV-NBJ6-ETJF. http://baywood.metapress.com/link.asp?id=e2lmjntvnbj6etjf.

Gifford, Robert. 1995. "Natural Psychology: An Introduction." *Journal of Environmental Psychology* 15 (3): 167–168.

Gill, David, and Victoria Prowse. 2012. "A Structural Analysis of Disappointment Aversion in a Real Effort Competition." *American Economic Review* 102 (1) (February): 469–503. http://ideas.repec.org/a/aea/aecrev/v102y2012i1p469-503.html.

Goldstein, Noah J., Robert B. Cialdini, and Vladas Griskevicius. 2008. "A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels." *Journal of Consumer Research* 35 (3): 472–482. doi:10.1086/586910. http://www.journals.uchicago.edu/doi/abs/10.1086/586910.

Gonder, Jeffrey, Matthew Earleywine, and Witt Sparks. 2012. "Analyzing Vehicle Fuel Saving Opportunities Through Intelligent Driver Feedback." *SAE Int. J. Passeng. Cars - Electron. Electr. Syst.* 5 (2): 450–461. doi:10.4271/2012-01-0494. http://papers.sae.org/2012-01-0494/.

Gonzales, Marti Hope, Elliot Aronson, and Mark A. Costanzo. 1988. "Using Social Cognition and Persuasion to Promote Energy Conservation: A Quasi-Experiment." *Journal of Applied Social Psychology* 18 (12) (September): 1049–1066. doi:10.1111/j.1559-1816.1988.tb01192.x. http://onlinelibrary.wiley.com/doi/10.1111/j.1559-1816.1988.tb01192.x/abstract.

Graving, Justin S., Michael P. Manser, and Ensar Becic. 2010. "Reduction in Fuel Consumption Depends on the Fuel Economy Display and Driver Sex: An Observed Interaction." In *Adjunct Proceedings of the Second International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI 2010)*, 11. Pittsburgh, Pennsylvania, USA. http://www.auto-ui.org/10/adjunctproceedings/p11.pdf.

Greene, David L. 1986. *Driver Energy Conservation Awareness Training: Review and REcommendations for a National Program*. http://www.ornl.gov/info/reports/1986/3445601391514.pdf.

GreenRoad. 2009. *GreenRoad and Admiral Partner to Launch "First Pay How You Drive" Insurance Scheme*. London, UK. http://greenroad.com/press-releases/greenroad-and-admiral-partner-to-launch-first-pay-how-you-drive-insurance-scheme/.

Gunel, Arhan. 2012. "OPower Enhances Other Energy-Efficiency Programs." In *Behavior, Energy, and Climate Change Conference*. http://beccconference.org/wp-content/uploads/2012/11/Arhan-BECC-presentation.pdf.

Gustafsson, Anton, Magnus Bång, and Mattias Svahn. 2009. "Power Explorer: a Casual Game Style for Encouraging Long Term Behavior Change Among Teenagers." In *Proceedings of the International Conference on Advances in Computer Enterntainment Technology*, 182–189. New York, NY, USA: ACM. doi:10.1145/1690388.1690419. http://doi.acm.org/10.1145/1690388.1690419.

Guttman, Nurit. 1997. "Beyond Strategic Research: A Value-Centered Approach to Health Communication Interventions." *Communication Theory* 7 (2) (May): 95–124. doi:10.1111/j.1468-2885.1997.tb00144.x. http://doi.wiley.com/10.1111/j.1468-2885.1997.tb00144.x.

Haakana, Maarit, Liisa Sillanpää, and Marjatta Talsi. 1997. "The Effect of Feedback and Focused Advice on Household Energy Consumption." In *European Council for an Energy-Efficient Economy (ECEEE) 1997 Summer Study*.

Halich, Greg, and Kurt Stephenson. 2009. "Effectiveness of Residential Water-Use Restrictions Under Varying Levels of Municipal Effort." *Land Economics* 85 (4) (November 1): 614–626. http://le.uwpress.org/content/85/4/614.abstract.

Harvey, Angela. 2013. "Montgomery Waterways Show Results from Bag Tax." *Capital Gazette*, February 2. http://www.capitalgazette.com/news/region/montgomery-waterways-show-results-from-bag-tax/article_61cb5676-1abf-5130-b478-fa5e2e3c88ad.html.

Hekler, Eric, Predrag Klasnja, Jon Froehlich, and Matthew Buman. 2013. "Mind the Theoretical Gap: Interpreting, Using, and Developing Behavioral Theory in HCI Research." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*, tbd. New York, NY, USA: ACM. doi:tbd. tbd.

Herlocker, Jonathan L, Joseph A Konstan, and John Riedl. 2000. "Explaining Collaborative Filtering Recommendations." In *Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work*, 241–250. New York, NY, USA: ACM. doi:10.1145/358916.358995. http://doi.acm.org/10.1145/358916.358995.

Hill, Charles A. 2004. "The Psychology of Rhetorical Images." In *Defining Visual Rhetorics*, ed. Charles A. Hill and Marguerite Helmers, 25–40. Mahwah, NJ: Lawrence Erlbaum Associates Publishers. http://psycnet.apa.org/psycinfo/2004-12251-001.

Hodge, Chelsea. 2010. "Do It In the Dark: Turn Off the Lights and Have Fun." In *Behavior, Energy, and Climate Change Conference (BECC)*. http://www.stanford.edu/group/peec/cgi-bin/docs/events/2010/becc/presentations/2C_ChelseaHodge.pdf.

Holstius, D., J. Kembel, A. Hurst, P. Wan, and J. Forlizzi. 2004. "Infotropism: Living and Robotic Plants as Interactive Displays." In *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*, 215–221. http://portal.acm.org/citation.cfm?id=1013145.

Höltl, Arne, Stefan Trommer, Caroline Schießl, Nicola Fricke, Maria Staubach, Roderick Hoek, Josep Laborda, and Guillem Bernatallada. 2012. *Requirements and Motivators for Private and Commercial Drivers*.

Honda. 2013. "Fuel Efficiency." http://automobiles.honda.com/insight-hybrid/fuel-efficiency.aspx.

Houde, Sébastien, Annika Todd, Anant Sudarshan, June A Flora, and K. Carrie Armel. 2013. "Real-time Feedback and Electricity Consumption: A Field Experiment Assessing the Potential for Savings and Persistence." *The Energy Journal* 34 (1): 1–34. http://www.stanford.edu/~shoude/FieldExperimentPowermeter_vfinal_July2011.pdf.

HouseOfLords. 2011. *Behavior Change*. *Science and Technology Select Committee, 2nd Report of Session 2010-12, Authority of the House of Lords*. London. http://www.publications.parliament.uk/pa/ld201012/ldselect/ldsctech/179/179.pdf.

Howard, George S. 1997. *Ecological Psychology: Creating a More Earth-Friendly Human Nature*. University of Notre Dame Press. http://www.amazon.com/Ecological-Psychology-Creating-Earth-Friendly-Nature/dp/0268009384.

IEE. 2012. *Utility-Scale Smart Meter Deployments, Plans, & Proposals*. http://www.edisonfoundation.net/iee/Documents/IEE_SmartMeterRollouts_0512.pdf.

Igarashi, Kohei, and Kazuo Tomita. 1983. "Apparatus for Indicating An Optimum Time to Shift a Manual Transmission Installed in a Vehicle". United States Patent.

Intille, Stephen S. 2002. "Designing a Home of the Future." *IEEE Pervasive Computing* 1 (2) (April): 76–82. doi:10.1109/MPRV.2002.1012340. http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=1012340.

Jamieson, Dave. 2011. "How Robert Solorzano Won Capital Bikeshare's Winter Weather Warrior Contest." *TBDOnFoot*. http://www.tbd.com/blogs/tbd-on-foot/2011/03/how-robert-solorzano-won-capital-bikeshare-s-winter-weather-warrior-contest-9603.html.

Jenness, James W., Jeremiah Singer, Jeremy Walrath, and Elisha Lubar. 2009. *Fuel Economy Driver Interfaces: Design Range and Driver Opinions (Report on Task 1 and Task 2)*.

Jones, Charisse. 2008. "Residents Reap Rewards for Recycling." *USA Today*, July 9. http://usatoday30.usatoday.com/news/nation/environment/2008-07-08-recycle_N.htm.

Kahneman, Daniel, Jack L. Knetsch, and Richard H. Thaler. 1991. "Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias." *American Economic Association* 5 (1): 193–206.

Katyal, Neal Kumar. 2002. "Architecture as Crime Control." *Yale Law Journal* 111. http://ssrn.com/abstract=290756.

Katzev, Richard D., and Theodore R. Johnson. 1987. *Promoting Energy Conservation: An Analysis of Behavioral Research*. Westview Press. http://www.amazon.com/Promoting-energy-conservation-behavioral-management/dp/0813373379.

Kaufman, Leslie. 2009. "Utilities Turn Their Customers Green, With Envy." *The New York Times*, January 30. http://www.nytimes.com/2009/01/31/science/earth/31compete.html.

Kimura, Hiroaki, and Tatsuo Nakajima. 2011. “Designing Persuasive Applications to Motivate Sustainable Behavior in Collectivist Cultures.” *PsychNology Journal* 9 (1): 7–28. http://www.psychnology.org/File/PNJ9(1)/PSYCHNOLOGY_JOURNAL_9_1_KIMURA.pdf.

Kohn, Alfie. 1999. *Punished by Rewards: The Trouble with Gold Stars, Incentive Plans, A’s, Praise, and Other Bribes*. 2nd ed. Mariner Books. http://www.amazon.com/Punished-Rewards-Trouble-Incentive-Praise/dp/0618001816.

Kollmuss, Anja, and Julian Agyeman. 2002. “Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to Pro-environmental Behavior?” *Environmental Education Research* 8 (3): 239–260. doi:10.1080/1350462022014540.

Koster, Raph. 2004. *A Theory of Fun for Game Design*. Paraglyph Press. http://www.amazon.com/A-Theory-Fun-Game-Design/dp/1932111972.

Kurani, Kenneth S., Jonn Axsen, Nicolette Caperello, Jamie Davies-Shawhyde, Peter Dempster, Marilyn Kempster, Kevin A. Nesbitt, and Tai Stillwater. 2010. *Plug-in Hybrid Electric Vehicle (PHEV) Demonstration and Consumer Education, Outreach, and Market Research Program: Volumes I and II*. http://publications.its.ucdavis.edu/publication_detail.php?id=1438.

Larson, Michael E., Daniel Houlihan, and Phillip N. Goernert. 1995. “Brief Report: Effects of Informational Feedback on Aluminum Can Recycling.” *Behavioral Interventions* 10 (2) (April): 111–117. doi:10.1002/bin.2360100207. http://doi.wiley.com/10.1002/bin.2360100207.

Laskey, Alex, and Ogi Kavazovic. 2011. “Opower: Energy Efficiency Through Behavioral Science and Technology.” *XRDS: Crossroads, The ACM Magazine for Students* 17 (4) (June 1): 47–59. doi:10.1145/1961678.1961687. http://dl.acm.org/citation.cfm?doid=1961678.1961687.

LCV. 2012. *League of Conservation Voters: 2012 National Environmental Scorecard of the Second Session of the 112th Congress*. http://scorecard.lcv.org/sites/scorecard.lcv.org/files/LCV_Scorecard_2012.pdf.

Lehman, Philip K, and E Scott Geller. 2004. “Behavior Analysis and Environmental Protection: Accomplishments and Potential for More.” *Behavior and Social Issues* 13 (2): 13–32.

Levy, Steven. 2011. “Brave New Thermostat: How the iPod’s Creator Is Making Home Heating Sexy.” *WIRED*, October. http://www.wired.com/gadgetlab/2011/10/nest_thermostat.

Locke, E. A., and G. P. Latham. 2002. “Building a Practically Useful Theory of Goal Setting and Task Motivation.” *American Psychologist* 57 (9): 705–717. doi:10.1037//0003-066X.57.9.705.

Lockton, Dan. 2010. “Learning from Game Design: 11 Gambits for Influencing User Behaviour.” *Architectures Blog*. http://architectures.danlockton.co.uk/2010/03/22/learning-from-game-design-11-gambits-for-influencing-user-behaviour/.

Lockton, Dan, David Harrison, and Neville Stanton. 2008. “Design with Intent: Persuasive Technology in a Wider Context.” In *Proceedings of the Third International Conference on Persuasive Technology (PERSUASIVE’08)*, ed. Harri Oinas-Kukkonen, Per Hasle, Marja Harjumaa, Katarina Segerståhl, and Peter Øhrstrøm, 5033:274–278. Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-540-68504-3. http://www.springerlink.com/index/10.1007/978-3-540-68504-3.

Lockton, Dan, David Harrison, and Neville a Stanton. 2010. “The Design with Intent Method: a Design Tool for Influencing User Behaviour.” *Applied Ergonomics* 41 (3) (May): 382–92. doi:10.1016/j.apergo.2009.09.001. http://www.ncbi.nlm.nih.gov/pubmed/19822311.

Loeb, Lorie, Gary Loeb, Evan Tice, and Tim Tregubov. 2010. “Emotionally Engaging Students to Change Behaviors and Conserve Resources: Unplug or the Polar Bear Gets It!” *International Journal of Environmental, Cultural, Economic, and Social Sustainability* 6 (2).

Lui, Claire. 2011. "Q+A with Ian Yolles of Recyclebank." *The Living Pricinples: Creative Action for Collective Good*. http://www.livingprinciples.org/qa-with-ian-yolles-of-recyclebank/.

Macnaghten, Philip. 1993. "Discourses of Nature: Argumentation and Power." In *Discourse Analytic Research: Repertoires and Readings of Texts in Action*, ed. E. Burman and I. PArker, 52–72. London, UK: Routledge.

Mahmud, Abdullah Al, Pavan Dadlani, Omar Mubin, A. Al Mahmud, Suleman Shahid, Cees Midden, and Oliver Moran. 2007. "iParrot: Towards Designing a Persuasive Agent for Energy Conservation." In *Persuasive Technology*, 64–67. Springer. doi:10.1007/978-3-540-77006-0_8. http://www.springerlink.com/index/835702R30516VRM3.pdf.

Makower, Joel. 2012. *State of Green Business*. *Green Biz Report*. http://www.greenbiz.com/research/report/2012/01/state-green-business-report-2012.

Manser, Michael P., Michael Rakauskas, Justin Graving, and James Jenness. 2010. *Fuel Economy Driver Interfaces: Develop Interface Recommendations (Report on Task 3)*.

Matsuoka, Yoky. 2012. "Nest Learning Thermostat's Auto Schedule Feature Reduces Residential Energy Usage." In *Behavior, Energy, and Climate Change Conference*. Sacramento, CA.

McCann, Barbara S., and Viktor E. Bovbjerg. 2009. "Promoting Dietary Change." In *The Handbook of Health Behavior Change*, ed. Sally A. Shumaker, Judith K. Ockene, and Kristin A. Riekert, 219–232. 3rd Editio. New York, NY, USA: Springer Publishing Company, LLC.

McGonigal, Jane. 2011. *Reality Is Broken: Why Games Make Us Better and How They Can Change the World*. Reprint ed. Penguin Books. http://www.amazon.com/Reality-Is-Broken-Better-Change/dp/0143120611/ref=sr_1_1?ie=UTF8&qid=1360451253&sr=8-1&keywords=jane+mcgonigal+reality+is+broken.

McKenzie-Mohr, Doug. 2011. *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing*. 3rd ed. New Society Publishers. http://www.amazon.com/Fostering-Sustainable-Behavior-Introduction-Community-Based/dp/0865716420.

Meddin, Russel, and Paul DeMaio. 2013. "The Bike-sharing World Map." *Google Maps*. http://goo.gl/XBUXg.

Mountain, D. 2006. *The Impact of Real-Time Feedback on Residential Electricity Consumption: The Hydro One Pilot*. *Mountain Economic Consulting and Associates Inc., …*. Ontario. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:The+Impact+of+Real-Time+Feedback+on+Resudential+Electricity+Consumption:+The+Hydro+One+Pilot#0.

NARUC. 2007. *Decoupling for Electric & Gas Utilities: Frequently Asked Questions*. http://www.epa.gov/statelocalclimate/documents/pdf/supp_mat_decoupling_elec_gas_utilities.pdf.

Nest. 2013. "Nest: Saving Energy." http://www.nest.com/saving-energy/.

Norman, Donald A. 2002. *The Design of Everyday Things*. Basic Books. http://www.amazon.com/Design-Everyday-Things-Donald-Norman/dp/0465067107.

NRDC. 2011. "Recyclebank's Success: A Q&A with Ian Yolles, Sustainability Director." *Natural Resources Defense Council: The Earth's Best Defense*. http://www.nrdc.org/business/design/ian-yolles.asp.

O'Connor, Ryan T, Dorothea C Lerman, Jennifer N Fritz, and Henry B Hodde. 2010. "Effects of Number and Location of Bins on Plastic Recycling at a University." *Journal of Applied Behavior Analysis* 43 (4) (January): 711–5. doi:10.1901/jaba.2010.43-711.

http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2998261&tool=pmcentrez&rendertype=abstract.

O'Dell, John. 2009. "Eco-Driving Systems: Now Your Car Can Gently Nag You Into Being More Fuel-Wise." *Edmunds AutoObserver*. http://www.edmunds.com/autoobserver-archive/2009/04/eco-driving-systems-now-your-car-can-gently-nag-you-into-being-more-fuel-wise.html.

Oskamp, Stuart. 2000. "A Sustainable Future for Humanity?: How Can Psychology Help?" *American Psychological Association* 55 (May): 496–508.

Oskamp, Stuart, L. Zelezny, P. W. Schultz, S. Hurin, and R. Burkhardt. 1996. "Commingled Versus Separated Curbside Recycling: Does Sorting Matter?" *Environment and Behavior* 28 (1) (January 1): 73–91. doi:10.1177/0013916596281004. http://eab.sagepub.com/content/28/1/73.short.

Parker, D., M. Mazzara, and J. Sherwin. 1996. "Monitored Energy Use Patterns In Low-Income Housing In A Hot And Humid Climate." In *Proceedings of the Tenth Symposium on Improving Building Systems in Hot Humid Climates*. Fort Worth, Texas.

Paulos, Eric, and Tom Jenkins. 2006. "Jetsam: Exposing Our Everyday Discarded Objects": 1–2. http://www.paulos.net/papers/2006/Jetsam (UbiComp 06 Demo).pdf.

Peffer, Therese, Marco Pritoni, Alan Meier, Cecilia Aragon, and Daniel Perry. 2011. "How People Use Thermostats in Homes: A Review." *Building and Environment* 46 (12): 2529–2541. doi:10.1016/j.buildenv.2011.06.002. http://www.sciencedirect.com/science/article/pii/S0360132311001739.

Petersen, John E., Vladislav Shunturov, Kathryn Janda, Gavin Platt, and Kate Weinberger. 2007. "Dormitory Residents Reduce Electricity Consumption When Exposed to Real-time Visual Feedback and Incentives." *International Journal of Sustainability in Higher Education* 8 (1): 16–33. doi:10.1108/14676370710717562. http://www.emeraldinsight.com/10.1108/14676370710717562.

Pierce, James, William Odom, and Eli Blevis. 2008. "Energy Aware Dwelling: A Critical Survey of Interaction Design for Eco-Visualizations." In *Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat*, 1–8. New York: ACM. http://portal.acm.org/citation.cfm?id=1517746.

Pol, Enric. 1993. *Environmental Psychology in Europe: From Architectural Psychology to Green Psychology*. Avebury. http://www.amazon.com/Environmental-Psychology-Europe-Architectural-Ethnoscapes/dp/1856285286.

———. 2006. "Blueprints for a History of Environmental Psychology (I): From First Birth to American Transition." *Medio Ambiente y Comportamiento Humano* 7 (2): 95–113.

———. 2007. "Blueprints for a History of Environmental Psychology (II): From Architectural Psychology to the Challenge of Sustainability." *Medio Ambiente y Comportamiento Humano* 8 (1 and 2): 1–28.

Pornpitakpan, Chanthika. 2004. "The Persuasiveness of Source Credibility: A Critical Review of Five Decades' Evidence." *Journal of Applied Social Psychology* 34 (2) (February): 243–281. doi:10.1111/j.1559-1816.2004.tb02547.x. http://doi.wiley.com/10.1111/j.1559-1816.2004.tb02547.x.

Portland. 2009. *City of Portland and Multnomah County Climate Action Plan 2009*. Portland, OR. http://www.portlandoregon.gov/bps/article/268612.

Progressive. 2013. "Snapshot Common Questions: Learn More About Our Pay As You Drive Program." http://www.progressive.com/auto/snapshot-common-questions.aspx.

Purpura, Stephen, Victoria Schwanda, Kaiton Williams, William Stubler, and Phoebe Sengers. 2011. "Fit4life: The Design of a Persuasive Technology Promoting Healthy Behavior and Ideal Weight." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 423–432. New York, NY, USA: ACM. doi:10.1145/1978942.1979003. http://doi.acm.org/10.1145/1978942.1979003.

Ravandi, Mehdi, Jon Mok, and Mark Chignell. 2009. "Development of an Emotional Interface for Sustainable Water Consumption in the Home." *Human-Computer Interaction. Ambient, Ubiquitous and Intelligent Interaction*: 660–669. http://www.springerlink.com/index/q50750863jr65713.pdf.

Recyclebank. 2011. *Get to Know Recyclebank*. http://www.recyclebank.com/media/Get_to_Know_Recyclebank_12.06.11.pdf.

Redström, Johan. 2006. "Persuasive Design: Fringes and Foundations." In *Proceedings of the First International Conference on Persuasive Technology for Human Well-being (PERSUASIVE'06)*, ed. Wijnand IJsselsteijn, Yvonne de Kort, Cees Midden, Berry Eggen, and Elise van den Hoven, 112–122. Springer-Verlag, Berlin, Heidelberg. http://dl.acm.org/citation.cfm?id=1986822.1986842.

Reeves, Byron, James J Cummings, James K Scarborough, June Flora, and Dante Anderson. 2012. "Leveraging the Engagement of Games to Change Energy Behavior." In *Collaboration Technologies and Systems (CTS), 2012 International Conference On*, 354–358. doi:10.1109/CTS.2012.6261074.

Rosenthal, Elisabeth. 2013. "Your Biggest Carbon Sin May Be Air Travel." *The New York Times*, January 26. http://www.nytimes.com/2013/01/27/sunday-review/the-biggest-carbon-sin-air-travel.html.

Runnion, Alex, Jesse Watson, and John McWhorter. 1978. "Energy Savings in Interstate Transportation Through Feedback and Reinforcement." *Journal of Organizational Behavior Management* 1: 180–191.

Russell, James. 2012. "Effective Behavior Change Through the Use of Real Time Data and Cross-Store Competition." In *Behavior, Energy, and Climate Change Conference (BECC)*. http://beccconference.org/wp-content/uploads/2012/11/BECC2012_Program_110712.pdf.

Ryan, Richard M, C Scott Rigby, and Andrew Przybylski. 2006. "The Motivational Pull of Video Games: A Self-determination Theory Approach." *Motivation and Emotion* 30 (4): 347–363. doi:10.1007/s11031-006-9051-8.

Ryan, Richard M., and Edward L. Deci. 2000. "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions." *Contemporary Educational Psychology* 25 (1): 54–12. http://www.sciencedirect.com/science/article/pii/S0361476X99910202.

Ryan, RM, and EL Deci. 2000. "Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-being." *American Psychologist* 55 (1): 68–78.

Sampei, Y, and M Aoyagi-Usui. 2009. "Mass-media Coverage, Its Influence on Public Awareness of Climate-change Issues, and Implications for Japan's National Campaign to Reduce Greenhouse Gas Emissions." *Global Environmental Change* 19: 203–212. doi:10.1016/j.gloenvcha.2008.10.005. internal-pdf://sampei.

Saunders, Carol D. 2003. "The Emerging Field of Conservation Psychology." *Human Ecology Review* 10 (2): 137–149.

Sawyer, Ben. 2010. "Issues of Gamification Design: Part 1." *Char 141 : Ben Sawyer's Personal Blog*. http://bensawyer.wordpress.com/2010/10/05/gamification-design-part-1/.

Schipper, L, S Bartlett, D Hawk, and E Vine. 1989. "Linking Life-Styles and Energy Use: A Matter of Time?" *Annual Review of Energy* 14 (1): 273–320. doi:10.1146/annurev.eg.14.110189.001421. http://www.annualreviews.org/doi/abs/10.1146/annurev.eg.14.110189.001421.

Schnelle, J. F., M. P. McNees, M. M. Thomas, J. G. Gendrich, and G. P. Beagle. 1980. “Prompting Behavior Change in the Community: Use of Mass Media Techniques.” *Environment and Behavior* 12 (2) (June 1): 157–166. doi:10.1177/0013916580122002. http://eab.sagepub.com/content/12/2/157.

Schultz, P Wesley, Jessica M Nolan, Robert B Cialdini, Noah J Goldstein, and Vladas Griskevicius. 2007. “The Constructive, Destructive, and Reconstructive Power of Social Norms.” *Psychological Science : a Journal of the American Psychological Society / APS* 18 (5) (May): 429–34. doi:10.1111/j.1467-9280.2007.01917.x. http://www.ncbi.nlm.nih.gov/pubmed/17576283.

Schultz, P. Wesley. 1999. “Changing Behavior With Normative Feedback Interventions: A Field Experiment on Curbside Recycling.” *Basic and Applied Social Psychology* 21 (1) (March): 25–36. doi:10.1207/s15324834basp2101_3. http://www.tandfonline.com/doi/abs/10.1207/s15324834basp2101_3.

Schwartz, Shalom H. 1977. “Normative Influence on Altruism.” *Advances in Experimental Social Psychology* 10: 221–279.

Seligman, Clive, Lawrence J. Becker, and John M. Darley. 1981. “Encouraging Residential Energy Conservation Through Feedback.” In *Advances in Environmental Psychology*, ed. A. Baum and J. E. Singer, 93–113. Hillsdale, NJ: Lawrence Erlbaum.

Senunas, Eric. 2012. “Gaming as an Energy Efficiency Behavior Tool.” In *Behavior, Energy, and Climate Change Conference (BECC)*. Sacramento, CA.

Sergici, Sanem, and Ahmad Faruqui. 2011. *Measurement and Verification Principles for Behavior-Based Efficiency Programs*.

Shove, E. 2010. “Beyond the ABC: Climate Change Policy and Theories of Social Change.” *Environment and Planning A* 42 (6): 1273–1285. http://www.envplan.com/abstract.cgi?id=a42282.

Siero, F. W., A. B. Bakker, G. B. Dekker, and M. T. C. Van Den Burg. 1996. “Changing Organizational Energy Consumption Behavior Through Comparative Feedback.” *Journal of Environmental Psychology* 16 (3): 235–246.

Simons, Herbert W, and Jean Jones. 2011. *Persuasion and Contemporary Culture*. Taylor & Francis. http://books.google.com/books?id=rDLtiCjQrYIC&pgis=1.

Simons, Stefan. 2012. “Five Years of Velib: How Cycling Became Chic in Paris.” *Spiegel Online International*, June 25. http://www.spiegel.de/international/europe/paris-bike-hire-scheme-is-five-years-old-a-840775.html.

Sintov, Nicole D., Greg Desario, and Carol Prescott. 2010. “Effectiveness of a Competition-Based Intervention in Promoting Pro-Environmental Behavior in a University Residential Setting.” In *ACEEE Summer Study on Energy Efficiency in Buildings*, 322–336. http://www.aceee.org/files/proceedings/2010/data/papers/2126.pdf.

Socolow, R. H. 1978. “The Twin Rivers Program on Energy Conservation in Housing: Highlights and Conclusions.” *Energy and Buildings* 1 (3): 207–242.

Steg, Linda, and Charles Vlek. 2009. “Encouraging Pro-environmental Behaviour: An Integrative Review and Research Agenda.” *Journal of Environmental Psychology* 29 (3) (September): 309–317. doi:10.1016/j.jenvp.2008.10.004. http://linkinghub.elsevier.com/retrieve/pii/S0272494408000959.

Stern, Paul C. 2000a. “Psychology and the Science of Human-environment Interactions.” *American Psychologist* 55 (5): 523–530. doi:10.1037//0003-066X.55.5.523. http://doi.apa.org/getdoi.cfm?doi=10.1037/0003-066X.55.5.523.

———. 2000b. “Toward a Coherent Theory of Environmentally Significant Behavior.” *Journal of Social Issues* 56 (3): 407–424. doi:10.1111/0022-4537.00175. http://dx.doi.org/10.1111/0022-4537.00175.

Stern, PC. 2011. “Contributions of Psychology to Limiting Climate Change.” *American Psychologist* 66 (4): 303–314. doi:10.1037/a0023235. http://psycnet.apa.org/journals/amp/66/4/303/.

Stillwater, Tai, and Kenneth Kurani. 2011. “Field Test of Energy Information Feedback: Driver Responses and Behavioral Theory.” *Transportation Research Record: Journal of the Transportation Research Board* (2252): 7–15. doi:http://dx.doi.org/10.3141/2252-02. http://pubsindex.trb.org/view.aspx?id=1093197.

Stillwater, Tai, and Kenneth S. Kurani. 2012. “Goal Setting, Framing, and Anchoring Responses to Ecodriving Feedback.” http://publications.its.ucdavis.edu/publication_detail.php?id=1660.

TerraCycle. 2013. “TerraCycle About Us.” http://www.terracycle.com/en-US/about-us.html.

Thieme, Anja, Rob Comber, Julia Miebach, Jack Weeden, Nicole Kraemer, Shaun Lawson, and Patrick Olivier. 2012. “‘We’ve Bin Watching You’: Designing for Reflection and Social Persuasion to Promote Sustainable Lifestyles.” In *Proceedings of the 2012 ACM Annual Conference on Human Factors in Computing Systems - CHI ’12*, 2337–2346. New York, New York, USA: ACM Press. doi:10.1145/2207676.2208394. http://dl.acm.org/citation.cfm?id=2207676.2208394.

Thøgersen, John. 2011. “Do Small Green Actions Lead to Bigger Ones – or to Lying and Stealing?” *The Guardian*, March 22. http://www.guardian.co.uk/sustainable-business/small-painless-behaviour-change.

Thomas, Jake. 2012. “Ann Arbor Rejects Recyclebank.” *Resource Recycling*. http://resource-recycling.com/node/2783.

Turner, Raviv. 2012. “We Bid You a Fond Farewell.” *Trash Tycoon Blog*. http://www.trashtycoon.com/2012/07/we-bid-you-a-fond-farewell.

Tversky, Amos, and Daniel Kahneman. 1991. “Loss Aversion in Riskless Choice: A Reference-Dependent Model.” *The Quarterly Journal of Economics* 106 (4): pp. 1039–1061. http://www.jstor.org/stable/2937956.

———. 2007. “The Framing of Decisions and the Psychology of Choice The Framing of Decisions and the Psychology of Choice” 211 (4481): 453–458.

Vining, J., and A. Ebreo. 1990. “What Makes a Recycler?: A Comparison of Recyclers and Nonrecyclers.” *Environment and Behavior* 22 (1) (January 1): 55–73. doi:10.1177/0013916590221003. http://eab.sagepub.com/content/22/1/55.abstract.

Volkswagen. 2009a. “The World’s Deepest Bin - Thefuntheory.com - Rolighetsteorin.se.” http://youtu.be/cbEKAwCoCKw.

———. 2009b. “Bottle Bank Arcade - TheFunTheory.com - Rolighetsteorin.se.” http://youtu.be/zSiHjMU-MUo.

Van der Voort, Mascha, Mark S Dougherty, and Martin van Maarseveen. 2001. “A Prototype Fuel-efficiency Support Tool.” *Transportation Research Part C: Emerging Technologies* 9 (4): 279–296. doi:10.1016/S0968-090X(00)00038-3. http://www.sciencedirect.com/science/article/pii/S0968090X00000383.

Wilson, Charlie, and Hadi Dowlatabadi. 2007. “Models of Decision Making and Residential Energy Use.” *Annual Review of Environment and Resources* 32 (1): 169–203.

doi:10.1146/annurev.energy.32.053006.141137. http://www.annualreviews.org/doi/abs/10.1146/annurev.energy.32.053006.141137.

Witmer, J F, and E S Geller. 1976. "Facilitating Paper Recycling: Effects of Prompts, Raffles, and Contests." *Journal of Applied Behavior Analysis* 9 (3) (January): 315–22. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1311944&tool=pmcentrez&rendertype=abstract.

Wu, May, Tom Osterhus, Pete Jacobs, and Patricia Thompson. 2012. *Impact & Persistence Evaluation Report: Sacramento Municipal Utility Distract Home Energy Report Program*. http://www.integralanalytics.com/ia/Portals/0/FinalSMUDHERSEval2012v4.pdf.

De Young, Raymond. 1996. "Some Psychological Aspects of Reduced Consumption Behavior: The Role of Intrinsic Satisfaction and Competence Motivation." *Environment and Behavior* 28 (3) (May 1): 358–409. doi:10.1177/0013916596283005. http://eab.sagepub.com/content/28/3/358.

De Young, Raymond, Sally Boerschig, Sarah Carney, Anne Dillenbeck, Mark Elster, Susan Horst, Brad Kleiner, and Bruce Thomson. 1995. "Recycling in Multi-family Dwellings: Increasing Participation and Decreasing Contamination." *Population and Environment* 16 (3) (January): 253–267. doi:10.1007/BF02331920. http://link.springer.com/10.1007/BF02331920.

Zhang, Yue, Jason I Hong, and Lorrie F Cranor. 2007. "Cantina: a Content-based Approach to Detecting Phishing Web Sites." In *Proceedings of the 16th International Conference on World Wide Web*, 639–648. New York, NY, USA: ACM. doi:10.1145/1242572.1242659. http://doi.acm.org/10.1145/1242572.1242659.

Gameography

Chris Crawford Games. 1990. *Balance of the Planet*, PC DOS, Chris Crawford Games

Guerillaapps, 2011. *Trash Tycoon,* Facebook Game, Guerillapps, http://www.trashtycoon.com/