Negabehaviors and Environmental Sustainability

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Abstract

Helping people learn to adopt more pro-social lifestyles usually involves persuading them to take new, beneficial actions. However, certain pro-social goals, such as achieving environmental sustainability, also require people to stop performing harmful actions—people are commonly instructed to drive less, use less electricity, and otherwise reduce the amount of resources they consume and waste they produce. In order to help people adopt this potentially unintuitive form of behavior change, we introduce a theoretical framework for the concept of "negabehaviors." A negabehavior is a manner of conducting oneself that supplants undesirable actions—that is, the behavior of not performing specific, undesirable actions. Negabehaviors are a variation on the idea of "negawatts" (a unit of energy saved through conservation), and offer a way to view and teach environmental sustainability that focuses on subtractive elements rather than additive ones. In this paper we present a framework and theoretical grounding for understanding negabehaviors. We discuss the relationship between negabehaviors and environmental sustainability, describing potential ways that this concept can be used in formal and informal sustainability education. By placing an emphasis on actions people need to stop taking, we can make it easier to encourage people to live more sustainable lives.

Key Words: negabehaviors, behavior reduction, environmental sustainability, sustainability education, persuasive technology

Introduction

For an increasing number of people, environmental sustainability is an important social goal that they wish to support. In order to contribute to achieving this goal, people often seek to adopt new pro-social actions and behaviors that can promote sustainability both in their personal lives and in their surrounding communities and world. For example, people may take actions ranging from recycling products, to replacing light bulbs, to planting or cultivating trees. By performing these actions, people can feel that they are working to support a more sustainable future. The desire to "take action" extends to the domain of sustainability education. Indeed, such an active (and

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proactive) stance offers a number of benefits for formal education; for example, action components can substantially increase students' engagement with the material while leading to notable local change (Church & Skelton, 2010). Informal sustainability education (such as through persuasive and technological systems, e.g. Woodruff, Hasbrouck, & Augustin, 2008; Paulos, Honicky, & Hooker, 2009) also often focuses on finding ways to take action, encouraging people to consider and adopt new behaviors. Thus individuals may support environmental sustainability by learning about new actions they can take in order to help.

However, not all societal problems require taking actions to address—some also require people to *stop* taking particular actions. Such behavior reduction is particularly applicable to environmental sustainability, which may require individuals to stop performing environmentally impactful actions, as well as performing new sustainable actions. Prominent accounts of sustainability such as the Brundtland Report (Brundtland & Khalid, 1987) acknowledge that humanity is currently having a significant impact on the environment, so that the capabilities of future generations to meet their needs cannot be sustained. In order to achieve such sustainability, humanity needs to reduce the environmental harm it is causing through the overconsumption of natural resources and the over-production of waste. To this end, people are commonly instructed to *avoid* environmentally impactful actions in order to live sustainability. They are told to drive less, fly less, use less electricity, and otherwise reduce the amount of resources they consume and waste they produce. Thus while new, beneficial actions are indeed an important component for sustainability, simultaneously reducing detrimental or ecologically harmful behaviors is also a significant and often overlooked requirement for achieving a sustainable future.

In order to emphasize this focus on behavior reduction, in this paper we introduce a theoretical framework for the concept of "negabehaviors"—the behavior of not performing specific, undesirable actions. While we are not suggesting that a focus on positive new actions is ineffective or unimportant for promoting sustainability, we believe that considering what unsustainable actions can be avoided or replaced is also a key component of achieving a sustainable future. Thus our conceptual framework offers an inverted, negative-space view of behavior change that can support personal and institutional environmental impact reduction. Such an inverted view may have a number of benefits including: helping people to avoid feelings of overall ineffectiveness common to individual sustainability efforts; de-familiarizing people's normal understanding of the impacts of their actions in order to enable effective exploration of sustainable behaviors; and providing an open-ended framing of sustainability that emphasizes the range of alternative actions and choices available in adopting sustainable lifestyles. In these ways, negabehaviors may offer an additional path by which individual behavior change may support environmental sustainability.

In the next section, we discuss some theoretical models of human behavior and behavior change that inform our framework. We then present our conceptual framework for negabehaviors, followed by an analysis of the relationship between negabehaviors and environmental sustainability. Finally, we discuss the potential benefits and uses of this framework for both formal and informal sustainability education. By offering an inverted view of sustainability that focuses on the actions and behaviors that people need to stop taking, negabehaviors may help in persuading and educating people to live more sustainable lives.

Persuading Behavior Reduction

The focus of the negabehavior framework involves persuading behavior reduction. Behavior reduction—what Fogg and Hreha (2010) call a "Gray Behavior"—is a form of behavior change that involves decreasing the frequency or presence of an undesired behavior, rather than encouraging the adoption or increase of a desired behavior. Behavior reduction can potentially lead to behavior cessation, so that the undesired behavior is not demonstrated at all. Behavior reduction, and behavior change in general, has been widely studied and examined through a variety of theoretical models. For example, the Transtheoretical Model (Prochaska & Velicer, 1997) presents a stage-based model for influencing behaviors that has been applied to both behavior adoption and behavior reduction. In particular, our conceptualization draws on previous research in developing persuasive technologies (e.g., Fogg, 2003) to influence behavior. We are interested in how social and technological systems can be used to persuade and educate people to adopt negabehaviors, and thereby engage in behavior reduction. While our theoretical perspective is rooted in understandings of technology and human-computer interaction, such a perspective is suitable to considering environmental issues, which involve humans interacting with complex ecological and climatic systems. Furthermore, persuasive technologies can be useful in supporting education (e.g., Lucero, Zuloaga, Mota, & Muñoz, 2006). Considerations of persuasive technologies are thus appropriate in developing a framework for use in formal and informal sustainability education contexts.

Persuasive technology has been used to encourage behavior reduction in a wide variety of domains, including health and social behaviors (see Ferebee, 2010 for a review). In particular, persuasive technology systems have been targeted at reducing energy use, often motivated by environmental sustainability (e.g., Arroyo, Bonanni, & Selker, 2005). Indeed, sustainability is becoming an increasingly prevalent topic in the development of interactive computational systems (DiSalvo, Sengers, & Brynjarsdóttir, 2010; Tomlinson, 2010). Our negabehavior framework builds on this prior research, offering a novel way to view and understand behavior reduction. Techniques and systems for encouraging behavior reduction have also been applied to formal education, such as with the Good Behavior Game (see Tingstrom, Sterling-Turner, & Wilczynski, 2006 for a review). While this system was developed to reduce disruptive behavior in grade-school classrooms, it has also been applied to behaviors outside of the classroom setting, such as oral hygiene. However, the Good Behavior Game focuses on using reinforcers (rewards) to discourage unwanted behavior, drawing from behaviorist psychology and operant conditioning. The negabehavior framework, on the other hand, aims to present an alternate, inverted viewpoint that can facilitate effective conceptualization of the required behavioral change by presenting the problem space in a new light.

Our focus on avoiding the performance of high-impact actions can be related to the Taoist concept of *wu-wei*. Often translated as "non-action," *wu-wei* is one of the fundamental tents of Taoism (Creel, 1982; Watts & Huang, 1975) and commonly understood as "going with the flow":

> "Thus *wu-wei* as 'not forcing' is what we mean by going with the grain, rolling with the punch, swimming with the current, trimming sails to the wind, taking the tide at its flood, and stooping to conquer. ...*Wu-wei* is a combination of this wisdom with taking the line

> of least resistance in all one's actions. It is not the mere avoidance of effort." (Watts & Huang, 1975)

In a way, the concept of negabehaviors draws on this meaning, encouraging people to not take actions that go against a natural flow and thus have an impact on the environment. However, the process of adopting a negabehavior does involve a certain level of effort and resistance: people may have to go out of their way to change their behavior, and not "go with the grain" of their normal lives as established by current social and cultural institutions. For example, avoiding driving a car may require extra effort from an individual as they figure out how to commute to work, purchase groceries, or perform other normal activities. Going with the flow of the natural environment may mean going against the flow of society at large—similar to "non-cooperation" as a form of civic activism crucial for social change (Gandhi, 2001). The process of adopting negabehaviors thus involves changing *which* flow a person is following, and may be an important component in effecting a sustainable society.

Activity Theory

Our formulation of the concept of a negabehavior is grounded in the behavioral model of Activity Theory (Leont'ev, 1978; Kaptelinin & Nardi, 2006). Activity Theory is an approach to understanding human behavior that focuses on *activities*—the interaction of a *subject* (e.g., a person) with the world. Kaptelinin & Nardi (2006) describe some basic principles of Activity Theory:

- *Object-orientedness:* In Activity Theory, all activities performed by subjects are directed at an *object* (i.e., an objective). This object can be either a physical thing ("I want grow a garden") or an ideal ("I want to reduce my carbon footprint"). The object acts as and represents the desired outcome that motivates a particular activity.

- *Hierarchical structure of an activity:* Activities can be broken down hierarchically into *actions* and then into *operations*. Actions are conscious processes that are directed at some goal needed to reach the object. While activities are tied to a specific object, different actions can be taken to reach the same goal. Operations are the unconscious, automatic processes that the subject takes as a way of performing an action. Note that a particular process can move between being an action and an operation depending on how much conscious attention it requires.

- *Internalization/Externalization:* Activity Theory differentiates between internal, mental processes and external, usually physical behaviors. An external activity can be internalized so that a subject can consider or mentally experiment with an interaction without actually performing a behavior. An internal activity can be externalized when it needs to be "repaired" or coordinated with other people.

- *Mediation:* Activity Theory emphasizes that activities are mediated by the use of *tools* of some kind that shape how humans interact with the world around them. Tools also embody a cultural and social knowledge of how it is used or an activity is performed.

- *Development:* Activity Theory also focuses on how human activity develops and unfolds over time and within a particular historical context. In fact, Activity Theory adopts development as a basic research methodology through the use of formative experiments and ethnographies.

We draw upon these principles in developing a framework for negabehaviors. For example, negabehaviors consider activities at the hierarchical level of actions—that is, conscious, goal-

directed behaviors—and uses this formulation to frame how people take (or do not take) particular actions. Although this focus on conscious thinking as a source of human action is not the only model for understanding human behavior (e.g., see Dourish, 2001), it is suitable for our goal of supporting the externalization (de-familiarization) and subsequent replacement of unsustainable activities. Furthermore, our suggested methods for using negabehaviors focus on how this view affects the tools (both physical and ideological) people use to achieve their goals, as well as how negabehaviors can influence and educate sustainable behavior at a particular moment and how that behavior can be developed over time.

Negabehaviors

In order to help support behavior reduction for environmental sustainability, we have developed a conceptual framework for the idea of a "negabehavior." This framework provides an inverted method for thinking about human action, which can externalize environmentally impactful activities in order to promote awareness and consideration, and thereby support the understanding and adoption of sustainable behaviors in a wider range of contexts.

A negabehavior is defined as "a manner of conducting oneself that supplants undesirable actions." Performing a negabehavior thus involves *not* taking a specific action (what we call taking a "non-action"), instead *replacing* that action with a different manner of acting, chosen from a wide variety of alternatives. In the language of Activity Theory, negabehaviors involve not taking a specific action towards a particular goal as part of fulfilling an activity's object. Thus one could perform the negabehavior of not driving (where driving is seen as ecologically harmful and hence undesirable) by using some other process or mediating tool, such as walking or taking public transportation, as part of reaching a target object (e.g., "going to the store," but also potentially broader objectives such as "getting dinner for the family"). A negabehavior is the behavior of not performing a specific, undesirable action that could otherwise be used to reach a goal that is situated within the context of an activity. Indeed, the action used to replace the undesirable behavior is less important in our framework—more significant is that the specific action is avoided. As such, we designate a negabehavior by the action that is *not* taken, rather than the action that is: a person performs the "not driving" negabehavior when he or she explicitly takes an action other than driving to achieve a goal. Performing negabehaviors still involves action substitution as part of behavior reduction, but negabehaviors focus on the replaced action (rather than the replacing action) in order to support behavior change through a variety of methods.

The idea of a negabehavior is a variation on two related concepts: "negawatts" (A. B. Lovins, 1990) and "negatechnologies" (A. B. Lovins, 2003). A negawatt (a play on the word "megawatt") is a unit of energy saved through conservation efforts, and represents a way that environmental sustainability can be made profitable and thus desirable for companies (see also von Weizsäcker, A. B. Lovins, & L. H. Lovins, 1997). This concept extends to the idea of negatechnologies—the replacing of inefficient or harmful technology with more efficient alternatives. For example, people could effectively produce negawatts (save energy) through negatechnologies by replacing old machines and appliances with newer, more energy-efficient versions (and in fact, the monetary savings of efficient technologies would more than offset the

cost of the replacement). The concept of negabehaviors is a direct extension of negatechnologies, moving from a focus on the replacement of undesirable technology to the replacement of people's undesirable behaviors[1]. Just as negawatts involve alternatives for undesirable energy use and negatechnologies involves alternatives for undesirable equipment, negabehaviors involve finding alternatives to undesirable human actions. However, our emphasis in defining negabehaviors is not on whether such behaviors would lead to monetary savings, as is the case with negawatts. Instead, we extend the concept of negawatts and negatechnologies in order to bring this view of environmental sustainability—the need to replace ecologically harmful elements as well as add new, better elements—to the foreground in the study of how to bring about new forms of human behavior.

A Negative Space View of Sustainability
All three of these concepts (negawatts, negatechnologies, and negabehaviors) offer ways to view environmental sustainability that focus on subtractive elements rather than additive ones—what we can remove or stop in order to help the environment, rather than what we should add. Thus these concepts apply a kind of "negative space" view to the challenge of sustainability. Negative space is a principal from art and design, and refers to the space around the subject of an image. By concentrating on the negative space when drawing, artists can create more accurate (and often more beautiful) drawings because they are able to forgo preconceived ideas of what a subject looks like; they can instead focus on drawing the edges as they appear from a particular perspective (Edwards, 1989).

Negabehaviors offer a similar approach to encouraging behavior change, such as for environmental sustainability. People who want to actively help the environment by reducing their impact are often told to (in effect) "go forth and do nothing": that they can help by not doing harmful actions, which often feels like *not* helping. But by focusing on negabehaviors—an active behavior of avoiding specific actions that otherwise would have been performed (or replacing them with less-harmful alternatives)—a kind of negative space, figure-ground inversion occurs that provides a useful framing for encouraging behavior change. Just as focusing on negative space in art helps artists to draw more accurately by ignoring preconceived bias, focusing on negabehaviors in persuasive systems can help people to adopt new behaviors by avoiding feelings of ineffectiveness. Indeed, a variation of this benefit has already been extended to the concept of "negative behavior spaces" in computer artificial intelligence systems (Tomlinson, 2005), which is the set of behaviors explicitly excluded from the capabilities of an AI system. This concept helps to reduce the scope of the task of implementing an intelligent agent by leaving out particular behaviors. Negabehaviors can have a similar benefit—focusing on avoiding or replacing specific actions can help make the process of working toward sustainability seem more manageable to people.

Negabehaviors provide an inverted view of human behavior, focusing on actions people do not take rather than actions they do. Nevertheless, any particular action can be viewed both as a negabehavior and as a non-inverted behavior. Indeed, the same behavior may be framed as both

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[1] Although such an extension may apply machine models to human behavior, such a framing is increasingly common and useful in related fields such as *human computation* (e.g., Ipeirotis, Chandrasekar, & Bennett, 2010).

a positive, helpful action and as a negabehavior non-action. For example, a common environmentally preferable action is to ride a bike to work—an action that can also be framed as the negabehavior "do not drive a car to work." Similarly, the negabehavior "do not use electricity to heat or cool your home" is often reframed in terms of positive actions like "insulate your windows" or even "turn off the lights." In considering ways to have a more environmentally sustainable lifestyle (or to achieve any desired objective), actions can be framed both as positive actions and as positive non-actions. So while negabehaviors are instantiated in the same way as many positive actions, they are understood from an alternate viewpoint—the concept of a negabehavior provides an inverted view for adopting behavior change that may help to simplify and make manageable the methods people may use to achieve objectives such as environmental sustainability. As a negative-space view of sustainability, negabehaviors de-familiarize people's normal understanding of sustainability—in terms of Activity Theory, negabehaviors externalize current activities that affect the environment. By bringing these activities to the foreground, our framework seeks to enable people to engage more effectively with the impact caused by their behavior, exploring and learning the variety of ways that they can reduce their impact on the environment.

Negabehaviors and Environmental Sustainability

We present the concept of negabehaviors as a framing that can help to encourage environmental sustainability by providing an alternate view of sustainability that focuses on not taking particular actions. Negabehaviors thus offer a framework for promoting behavior reduction for sustainability. Indeed, negabehaviors emphasize stopping undesirable actions—implying the underlying assumption that sustainability requires people to stop taking their current actions. This framing presupposes that many people live lives that are currently unsustainable, and cannot be made sustainable only by taking new, positive actions. Instead, people need to stop doing many of the wide range of actions and behaviors that are currently causing ecological harm and damage to the environment. We as a civilization cannot simply maintain the status quo—we need to actively reduce our harmful impact on the environment by changing our lifestyles. Indeed, the Brundtland definition of sustainability directly suggests the need for a kind of global negabehavior: avoiding the behavior of "compromising the needs of the future."

This is not to say that adopting negabehaviors to reduce ecologically harmful actions is the only behavior needed to achieve a sustainable future (though it is an important component). Humanity is past the point of being able to sustain the global ecology simply by refraining from causing further impact. Positive new actions are an important part of the restoration and repair of environmental damage that has been caused, and of developing new social and technological systems that can enable a greater number of people to reduce their unsustainable behavior. Nevertheless, considering sustainability in terms of non-actions and negabehaviors is particularly appropriate for topics such as resource consumption and waste production, both of which need to be reduced by not taking certain actions (i.e., actions that consume resources or produce waste), or replacing those actions with more sustainable alternatives. Although there are other important facets to achieving environmental sustainability, we feel that these areas are tightly integrated with common aspects of human behaviors that need to be altered if we are to reach a sustainable future. The concept of a negabehavior allows us to position these non-actions more easily as

active behaviors, thus making such aspects of sustainability (the reduced consumption of resources and production of waste) into a more manageable, achievable goal.

However, this framing of negabehaviors for sustainability does not exclude the possibility of complications from rebound effects. Because negabehaviors focus on the undesirable action to be avoided rather than the substituted action, it is possible that the replacement action could be environmentally worse than the behavior it replaces—a case of the cure being worse than the disease. For example, if a person tries to perform a "do not fly" negabehavior by instead driving across the country, it is possible that they will have produced greater carbon emissions through the non-action than through the undesirable action they sought to avoid. This is a similar effect to the Khazzoom-Brookes Postulate (Saunders, 1992), which proposes that increasing energy efficiency may actually lead to increased energy consumption. Indeed, these kinds of paradoxes abound in discussions of environmental sustainability (Tomlinson, Silberman, & White, 2011). Although environmental action (particularly around technology) is often framed as being focused on "reuse" (e.g., Blevis, 2007; Huh, Nam, & Sharma, 2010), sometimes reusing old devices or systems is as harmful or worse than replacing them (Sahni, Boustani, Gutowski, & Graves, 2010), hence the concept of negatechnologies. It is possible that negabehaviors may be able to reduce the presence of these paradoxes by providing a simple framing for avoiding undesirable actions. Although we focus on encouraging the replacement of environmentally impactful behaviors with alternatives that are not likely to be even more ecologically harmful, the avoidance of rebound effects remains a challenge when encouraging negabehaviors and sustainable behaviors in general.

Our framework for negabehaviors involves individual actions and encouraging individual sustainability, rather than institutional or societal change. This framing is often adopted in discussions of sustainability—for example, common carbon footprint calculators do not include the carbon footprint of the social infrastructure in which users live, such as the carbon footprint of the government bureaucracy (Ross, Shantharam, & Tomlinson, 2010). In this view, sustainability comes about from the activities of individual people, instead of larger institutions or even of society as a whole. This framing has been justifiably critiqued (e.g., Dourish, 2009) as limiting sustainability to behaviors within a market context (e.g., the commodities that people purchase) and turning sustainability into a "personal, moral choice" available only to those with the economic means to afford it. Nevertheless, we believe that encouraging individual environmental sustainability should co-exist with efforts to increase sustainability on an institutional level. Achieving sustainability is a wicked problem, and thus should be approached through simultaneous engagement on multiple fronts—both individual and institutional changes are necessary. Furthermore, the rise of participatory culture (Jenkins, 2006) has begun to blur the previously crisp separation between individuals and organizations, so that personal change can blend more readily into institutional change. Efforts at collective action (or in this case, non-action) help individuals work together to effect change at larger scales (Tomlinson, 2010). Finally, it is possible for the concept of a negabehavior to be extended to larger groups and institutions, with whole organizations avoiding specific, organization-level actions.

Negabehaviors and Sustainability Education

Negabehaviors can play a role in supporting sustainability education in a variety of human contexts. The negabehavior framework can support sustainability education primarily by inverting people's view of sustainability and helping them to consider their current (rather than hypothetical) effects on the environment. In this section, we suggest some specific ways that this inverted view of sustainability can be applied in formal and informal educational contexts.

Formal Education Contexts

Negabehaviors can be built into various curricula to help students become more engaged with sustainability issues and to develop a deeper understanding of the complex relationship between human behavior and the environment. For example, negabehaviors can be used at the grade-school level as a framing for formal science lessons. Students could first use an online carbon calculator to determine their carbon footprint and thereby the environmental impact of different aspects of their current behaviors. By analyzing these data (using graphs, statistics, and other scientific methods), students could ascertain the actions they and their families may need to stop taking—from reducing electricity usage at home to avoiding unsustainable prepackaged lunches. Students could then identify and discuss the wide variety of alternate actions that they may be able to take in the negabehaviors of replacing these undesirable behaviors—indeed, the negabehavior focus on the action to be replaced encourages such a discussion and analysis of alternatives. Finally, students could be encouraged to adopt these alternate behaviors (either within or outside the context of the time spent in school), and then to measure their reduced environmental impact. Negabehaviors can thus promote active, constructivist learning, as students consider and weigh different options for replacing undesirable behaviors.

The way that negabehaviors focus on a distinct behavior to avoid rather than a specific way to replace that behavior emphasizes the range of alternative actions and choices available in adopting sustainable lifestyles. People often think of being sustainable as limiting their options; the open-ended framing of negabehaviors makes this requirement seem less prohibitive. Furthermore, the fact that negabehaviors do not require a specific set of actions to be taken can help to prevent the adoption of these sustainable efforts from being limited to certain students (e.g., of a certain socioeconomic status). Because negabehaviors can involve a variety of alternative actions, students would be able to adopt one of many alternate behaviors in order to reduce their environmental impact in a manner suitable to their personal context and situation.

One role of formal education is to help students understand things that they may not be exposed to in their everyday lives. The fact that negabehaviors represent a framing different from most people's default view of the world can help students to understand their lives in a new way. Understanding negabehaviors require taking a (potentially unintuitive) point of view that focuses on the absence or inversion of a behavior. Being able to adopt this negative-space point of view—and switch between it and a normal "direct" view—can enable students to better understand and engage with the complex sets of concepts that make up the topic of "environmental sustainability."

Informal Education

Negabehaviors can also be used in informal education and learning outside of a school context. For example, an increasing amount of informal learning occurs through the use of games— particularly video games (see Gee, 2007). These "serious games" (Sawyer & Smith, 2008) are being used for learning and training in a variety of ways, as well as for encouraging behavior change and social action. Games offer fun and interactive experiences that can engage people in learning and addressing social problems. People (and children in particular) are eager to play and experiment with games, and thus can develop both a deep understanding of games' system model and an empowering emotional connection to games' content. Pervasive games (Montola, Stenros, & Waern, 2009) that turn aspects of everyday life *into* a game may be particularly good at motivating behavior change, as people change their behavior in order to play the game. Although pervasive games have been developed that encourage and environmentally sustainable behavior (e.g., Bang, Gustafsson, & Katzeff, 2007; Eklund, 2007), such systems usually focus on encouraging people to adopt new beneficial behaviors, rather than to avoid undesirable actions.

Thus we are currently developing *Negabehavior Games*—pervasive games that encourage negabehaviors in order to support environmental sustainability. These games can help people to gain a new understanding of sustainability while reducing their environmental impact. These games will encourage players to adopt negabehaviors by making the performance of non-actions into a key component of game-play. For example, a game may challenge players to "hide" from their opponents (either fictional antagonists or even other players) by avoiding specific actions that will cause them to get "caught." Thus the primary goal of the game (avoid being caught for as long as possible) requires players to perform a negabehavior—people play and win the game by taking non-actions. In this way, playing a Negabehavior Game will require people to change their everyday behaviors simply in order to play and win the pervasive game. By having these games offer progressively more difficult game-play (increasing both the scope and duration of the adopted negabehaviors), we can engage players through skill-appropriate challenges and potentially help promote long-term behavioral change through active, critical learning. Furthermore, carefully designed game narratives (Dickey, 2006) can help players learn how and why they should take non-actions as part of a negabehavior, supporting players in understanding behaviors in terms of negative space. Thus these games use negabehaviors to provide a framework for informal learning about environmental sustainability.

Conclusion

In this paper we have presented a theoretical framework for the concept of negabehaviors—an inverted, negative-space view of sustainability that focuses on the avoidance and replacement of current undesirable behaviors. We have discussed how this concept can be applied to environmental sustainability in order to persuade people to reduce their environmental impact, as well as how it can be used for sustainability education. Indeed, negabehaviors may be able to have an impact on global sustainability by emphasizing the subtractive elements of sustainability—what should be stopped or taken away—rather than the additive ones. This novel framework for understanding the ways in which people affect the environment may thus be able to help persuade people to change their daily behaviors and live greener lives.

Nevertheless, further research is needed to determine under what circumstances a negabehavior focus on an action to be replaced may be more effective at persuading behavior change than a focus on the substituting action. It is likely that in a variety of contexts, providing a clear action item (e.g., "take a bike to work") would be more helpful than providing a clear goal (e.g., "do not drive to work"). For example, a negabehavior view may be more suitable when people are engaged in finding creative solutions to sustainability, or when standard behavior suggestions are unfeasible due to individual circumstances.

While the focus of this paper has been conceptualizing negabehaviors for environmental sustainability (that is, the undesirable actions being replaced are undesirable in an environmental context), the negabehavior framework can easily be applied to a variety of other domains. For example, negabehaviors could be applied to public health, another common intervention area for persuasive systems and technologies (e.g., Fujiki et al., 2008; Khaled, Barr, Fischer, Noble, & Biddle, 2006; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006). The concept of a negabehavior could be a way to frame activities such as "not smoking" or "not eating unhealthy food." Negabehaviors could also be applied to the domain of personal privacy. To some extent, retaining personal privacy involves avoiding the action of giving out personal information—thus a privacy-based negabehavior could be of the form: "do not tell people your address." Negabehaviors encourage stopping undesirable actions, but the way in which that action is undesirable can be defined by a system's context and purpose. Thus the conceptual framework for negabehaviors we present in this paper has the potential to be used in a wide variety of interventions across an array of persuasive and educational systems and technologies.

Acknowledgments

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