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Will they recycle? Design and implementation of eco-feedback technology to promote on-the-go recycling in a university environment

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ABSTRACT

Recycling rates have plateaued and recycling in public spaces has been targeted as a component that can help increase overall recycling rates. Eco-feedback technology and environmental psychology were combined to study recycling in a semi-public space in multiple social environments. A low-cost, low-energy electronic recycling bin design (WeRecycle bin) uses human-computer interaction and social principles to provide behavior-changing eco-feedback. Using mixed-methods research, we tested the WeRecycle bin in three different experiments by varying social settings and time of exposure, documenting impacts for public recycling. Results show that simple low-energy, low-cost eco-feedback technology resulted in statistically significant increases in recycling activity and can be an important tool in the promotion of recycling activity outside the home.

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1. Introduction

The research presented in this paper focuses on the design, implementation, and analysis of eco-feedback technology with the goal to promote recycling in public spaces (on-the-go recycling). On-the-go recycling is common terminology for recycling that occurs outside the home. In 2013, Americans generated 254 million tons (230 million metric tons) of waste or 4.4 lb (2 kg) of waste per person per day, with an average of 2.44 lb (1.1 kg) of waste generated per individual at public events (U.S. EPA, 2015; Cascadia, 2006). The overall recycling rate for the U.S.A. was 34.3% of this solid waste, or 87 million tons (79 million metric tons) (U.S. EPA, 2015). On-the-go recycling represents an important part of capturing more recyclables and increasing the recycling rates in the U.S.A. and worldwide.

We conducted a mixed methods study (including qualitative methods in addition to quantitative data) on recycling behavior related to several interventions in a university setting. We chose the university setting to be able to manipulate the power of context for both organizational change and waste-related behavior change (Gladwell, 2000; Spehr and Curnow, 2015). The technological focal point of this study is a "smart" recycling bin (WeRecycle bin), a recycling bin augmented with sensors to count recycled items and eco-feedback technology to solicit and promote recycling. From a sensing perspective, this concept is not entirely new. Popular commercial/electronic approaches include the SmartBin products (SmartBin, n.d.) and the Dream Machine (PepsiCo, n.d.), among others (Chen, 2012; Dyscario, n.d.). However, these types of bins are limited by geographical unavailability and lack of user feedback at market price (PepsiCo, n.d.). In an iterative design, our first generation smart bin received valuable input from peers to make it more attractive (e.g., adding numerical LED screen and attention grabbing lights while decreasing the duration of the audio file), leading to the second generation bin, the WeRecycle bin.

While the concept of making a pro-environmental activity "fun" or interesting has been explored previously (Thieme et al., 2012; Lockton, 2009; Holstius et al., 2004; Stern, 1999; Wang and Katzev, 1990), our approach was different in that it was developed considering materials and energy conservation through the Principles of Green Engineering (Anastas and Zimmerman, 2003) (other application-focused designs provided feedback without an explicit concern for energy usage or modularity). This is an important environmental issue since modularity could avoid obsolescence through parts replacement, therefore reducing waste (Anastas and Zimmerman, 2003). For energy usage, we designed the circuit to keep power demand as low as possible, since if energy savings from recycling are not more than the energy used by the bin, there will be

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no energy benefit of recycling (Attari et al., 2010). Additionally, we reduced costs by using the minimum technology for eco-feedback.

In this paper, we explore how technology and factors of social change could play a role in the management of waste in public spaces, in this case, recycling. Based on the three factors of social change: *Context, Innovators,* and *Stickiness factor* (Gladwell, 2000) and some waste behavior related factors: *Environment, People,* and the *Ickiness factor* (Spehr and Curnow, 2015), we believe that a technologically-enhanced feedback-providing bin could be an important agent of change. Specifically, we examined the following questions: (1) Does a technologically enhanced bin capture the attention of people otherwise engaged during the cultural setting of a sports event? (2) Does the WeRecycle bin spark the same interest as an interactive non-technological bin? (3) Does a technologically enhanced recycling bin divert recycling from other non-technological ones?

2. Background

Independent of the morality of working in community to achieve a more sustainable way of life, recycling takes time, effort, and can be a challenging endeavor. Thanks to a widespread out-of-sight-out-of-mind attitude, there is little motivation to pursue solutions for a problem that, traditionally, has been managed by other people (e.g., large companies and governments) (Thogersen, 1996). So it is not surprising to find lack of participation in activities such as recycling, or even water and energy conservation (Berglund and Matti, 2006). Research in environmental psychology attempts to understand individual commitment to environmentally conscious activities and, as such, is essentially a cognitive approach. On the other hand, human-Computer Interaction (HCI) research typically follows behaviorist methodology, focusing on designs that yield desired outcomes.

Despite differing philosophical underpinnings, both disciplines agree on the importance of analyzing human behavior as a factor in successful pro-environmental interventions, convergence that has been rarely reflected in practice. In a 2010 article, Froehlich et al. compared and contrasted studies in HCI and environmental psychology, specifically in evaluation, experimentation, and analysis techniques. So, from the technological perspective, the study highlighted the need for interactivity, information presentation, and context, but from a holistic perspective it suggested synergy between the two disciplines for more effective approaches.

Numerous environmental activities were explored in Froehlich et al. (2010), however, when it came to municipal solid waste they highlighted a significant trend. From 139 studies in HCI and 82 studies in environmental psychology, 27 were specific HCI systems analyses and 12 were environmental psychology involving eco-feedback technology. Although 24 papers addressed energy consumption, only 3 targeted solid waste management and recycling. The authors suggest that this discrepancy may be due, in part, to the particular challenges posed in modifying solid waste management and recycling behaviors. These challenges also play a role in mismanaged (e.g., littered) waste, along with logistics which include location and availability of bins (Spehr and Curnow, 2015).

Solid waste management, relative to water and energy conservation, is a more complicated undertaking, requiring considerable effort for people (vonBorgstede and Biel, 2002; Schultz and Oskamp, 1996). Schultz and Oskamp (1996) suggest that recycling creates additional cognitive and physical challenges since we each must choose what to recycle. Furthermore, on-the-go recycling, by virtue of its public nature, poses visibility and accessibility challenges (London, 2009). According to London (2009), innovative approaches and interventions are needed to inspire and motivate people to manage solid waste and recycle. In addition, the challenge becomes greater when trying to engage entire communities in different social environments (e.g., micro vs. macro scales).

Analyzing community pro-environmental behavior requires a broader social context than individual behavior. In this regard, social work explores how individual behavior is influenced by interactions among micro, mezzo, and macro systems. Micro and mezzo systems center on individuals and close groups surrounding them, macro systems include cultures, communities, institutions, and organizations. Interactions between social systems depend greatly on the type of structure they are a part of. For instance, organizations (macro structure) are composed of people with a mutual goal (mezzo context), who perform established activities (micro tasks). Communities, less structured, are people with commonalities that connects and distinguishes them from others (Zastrow and Kirst-Ashman, 2010).

The change process in organizations and communities is similar, but in this paper we will work primarily with the principles of organizational change. The first principle, the law of the few, refers to the importance of people (innovators, ambassadors, "salesmen, connectors, and mavens" (Gladwell, 2000)) on changing people. The principle of "stickiness factor" requires something to keep the new phenomenon interesting. And, the "power of context" relates to community exploration to understand and work in the target environment (Burke, 2011). Furthermore, Gladwell (2000) noted that most successful community behavior interventions generally adhere to these principles.

In order to complement and bound the study, we will also address some common waste behavior factors. Mirroring the organizational change principles, we will focus on the *environment, people, and ickiness* factors in waste behavior, which influence how people manage waste in public settings (Spehr and Curnow, 2015). According to Spehr and Curnow (2015), an ideal environment would be one displaying cleanliness and care (i.e., setting a clear context goal). This is a demonstration of how other people treat and feel about the place, thus guiding people's behavior. As a representation of a personal barrier to push through in order to make a behavior permanent, we will focus on the association between trash and germs that pervades developed societies, the *ickiness factor* (Spehr and Curnow, 2015). We will address relevance of the principles and factors in the results section as we discuss the organizational characteristics of our target system, a university setting.

Previous research on recycling in university settings has revealed benefits in analyzing the community during the design of recycling strategies. For instance, one study suggested visibility, convenience, and information are synergetic in encouraging a recycling mentality among university communities (Kelly et al., 2006). On the other hand, another study found that information about amount and type of recycled material filled an information gap that people find discouraging when recycling (Katzev and Mishima, 1992). For recyclers, the latter is a "peek behind the [recycling] curtain," which increased their desire to participate in recycling (Katzev and Mishima, 1992). Both cases agree that providing information or feedback appeared to motivate recycling behaviors.

Information and feedback are key elements in promoting behavioral change as long as they are explored within the proper context. Within a micro social environment, behavioral changes occur based on individual perceptions and reactions to timely interventions. However, it is undeniable that mental processes influence the action-axiom of present and future experiences even when a behavior is specifically related to certain stimulus (Boettke and Leeson, 2006). In other words, our actions are directly or indirectly related with the notion of our previous knowledge or a set of preconceived notions coming from past experiences (a priori) and learning outcomes.

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