One Save per Day

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One Save per Day: How mobile technology can support individuals to adopt pro-environmental behaviors

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Abstract

The pressing issue of climate change requires humanity to reduce its ecological footprint drastically. While policymakers and companies must ensure the availability of green options, individuals are requested to contribute to the reduction of carbon emissions substantially. However, even when individuals recognize the need for pro-environmental behaviors, they often have difficulty meeting their expectations. Mobile technology for sustainability has the potential to support them in overcoming this issue by providing the decisive impetus for environmentally friendly behavior. Drawing upon the affordance perspective, we conducted a longitudinal qualitative study with users of a mobile app that encourages individuals to take daily sustainable actions. We present the affordance strands made possible by the app's features and how they lead to environmentally-friendly behaviors. We could observe behavior change with the app's features. We also identify enablers and obstacles to affordance actualization. Our study contributes to Green IS research at the individual level and provides practical implications for mobile technology providers.

Keywords: Green IS, sustainability, behavior change, affordance theory, challenges, mobile app

1. Introduction

A recent report published by the World Meteorological Organization predicts a 50% chance that global warming may exceed 1.5 degrees Celsius at least once in the next five years. This temperature increase is alarming as scientists describe it as the critical threshold for dramatic impacts of climate change (e.g., wildfires, heatwaves, rising sea levels) that will have irrevocable consequences for humanity and our planet (World Meteorological Organization, 2022). Governments have signed the Paris Climate Agreement to limit global warming and committed to drastically reducing climate gas emissions in the coming decades. However, to achieve this goal, governments must make this pressing issue a top priority and engage both, organizations and individuals to shift their production and consumption behaviors in a more environmentally friendly direction (Thøgersen, 2021).

According to the Paris Agreement (2015), a promising strategy for supporting organizations and individuals to act sustainably is using technology. Therefore, information systems (IS) research has the responsibility to contribute to climate change resilience by investigating and enabling technological innovations. So far, IS research has predominantly investigated society's environmental impact from an organizational perspective. Scholars discussed, for example, the sustainable design of IT systems (Dedrick, 2010; vom Brocke et al., 2013) or the potential of IS to create organizational environments that encourage pro-environmental behaviors (Hedman & Henningsson, 2016; Loeser et al., 2017; Seidel et al., 2013). At the individual level, IS research focuses primarily on the role of IS in energy conversation behavior (Corbett, 2013b; Loock et al., 2013; Tiefenbeck et al., 2018).

To gain control over the dramatic dynamics of climate warming, however, it is important to extend our endeavors and educate individuals on further environmentally friendly behaviors. Prior research has shown that taking individual actions (e.g., shifting diets, changing transport behavior, and reconsidering consumption) can make a substantial difference in reducing greenhouse gas emissions (for a literature review see Thøgersen, 2021). Moran et al. (2020), for example, demonstrate that encouraging sustainable behavior on an individual level can reduce the CO2 footprint in Europe by 25%. While most individuals agree that they want to protect the environment and behave environmentally friendly, they find it difficult and challenging to achieve this goal and implement sustainable patterns in their daily lives (Tiefenbeck et al., 2018).

Mobile technology for sustainability (e.g., mobile apps) has the potential to support individuals in overcoming this issue and guide them toward environmentally friendly actions. Due to their ubiquity, proximity to the individual, and high frequency of interaction, mobile technologies can give individuals the impetus they need at the right moment to change their behavior. While the effectiveness of

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mobile technologies in changing individual behaviors has been shown in the context of health (Lehrer et al., 2021), household energy consumption (Weiss et al., 2012), and green mobility (Froehlich et al., 2009; Tulusan et al., 2012), we know little about how mobile apps can encourage individuals in the development of daily sustainable routines in different aspects of life. This is particularly important as individuals have to engage in various integrated actions to achieve the anticipated CO2 reduction of 25% (Moran et al., 2020).

Therefore we ask, *how can mobile technology support individuals to adopt pro-environmental behaviors across different action areas?* To address this research question we drew on the affordance perspective and conducted a longitudinal qualitative study with nine individuals using the mobile app "OneSave/Day", which provides behavior change techniques to help people act more sustainably in their daily lives.

The paper is structured as follows: After outlining the theoretical foundations of our research in the next section, we describe our research approach and present our results. We close by discussing implications for theory and practice.

2. Theoretical background

2.1 Green IS

The increasing awareness for environmental issues has encouraged IS scholars to investigate the impact of technology on environmental sustainability (Watson et al., 2010). Subsumed under the umbrella of "Green IS", research in this IS subfield has studied how technology can be used to enable and support pro-environmental behavior (Watson et al., 2010). In contrast, "Green IT" research focuses on the direct negative impact of IT infrastructures on the environment and investigates how IT can be designed to enable environmental sustainable business processes (Dedrick, 2010; vom Brocke et al., 2013). The example of carbon emissions can illustrate the difference between these two research perspectives. It is argued that 2% of global greenhouse gas emissions are traceable to technology. While Green IT aims to mitigate this effect through the utilization of energy-efficient IT resources (Dedrick, 2010), Green IS offers a broader perspective and discusses technology-enabled solutions for sustainable behavior change to reduce the remaining 98% of emissions that are not directly attributable to technology (vom Brocke et al., 2013; Watson et al., 2010). The research presented in this paper falls into the stream of Green IS studies.

Much of the current literature on Green IS pays particular attention to the organizational level that investigates environmental sustainability from a strategic top-down perspective and discusses how organizational decision makers promote technology-enabled sustainability endeavors (Loeser et al., 2017; Seidel et al., 2013). For example, Seidel et al. (2013) present functional affordances that transform organizational practices toward a sustainability-oriented mindset. In the same vein, Loeser et al. (2017) show how environmental aspects can be integrated into a company's strategy to encourage Green IS initiatives that lead to further desirable organizational outcomes (e.g., cost reductions, positive reputation). In contrast, Hedman and Henningsson (2016) argue that Green IS initiatives can also evolve from a bottom-up process when employees with a high awareness for environmental sustainability speak out and promote Green IS approaches toward the organizational agenda.

In addition to research at the organizational level, there is a growing body of literature investigating the effect of technology on environmental sustainability at the individual level. To date, several studies have investigated the implications of IS for energy conservation behavior. A prominent study of Loock et al. (2013), for example, found that IS can stimulate energy-efficient behavior in households by providing the option of goal setting and defaults through a web interface. This view is supported by other research that reported the positive effects of smart meters on individuals' energy efficiency (Corbett, 2013b) and showed that real-time feedback provided by a smart device displaying the resource consumption of a shower reduces individuals' energy consumption (Tiefenbeck et al., 2018). Taken together, these studies emphasized individuals' important role in actively addressing sustainability issues and moving toward more eco-friendly behaviors. Thereby, they acknowledge the relevance of individuals' rationality to understand the consequences of their behavior as an essential enabler of a more sustainable future (Elliot, 2011; Melville, 2010). Moreover, the presented studies highlight the need for and potential of IS interventions aiming to educate and inform individuals about the environmental impact of their consumption behaviors and activities (El Idrissi & Corbett, 2016). However, reasonable energy consumption is just a tiny part of eco-friendly behavior at the individual level (Elliot, 2011) and IS research activities are not limited to this particular domain (Pan et al., 2022). In her study of carbon management systems, Corbett (2013a), for example, takes a broader perspective and shows that mirroring all activities and behaviors that contribute to the ecological footprint support employees to act in an

ecologically responsible way. In contrast, Tim et al. (2018) believe that environmental sustainability can best be achieved in a community of motivated individuals that take various actions against climate change. So far, however, little is known about how the integration of various individual actions in a green community enabled by a mobile app can shape pro-environmental behavior.

2.2 Mobile technology for sustainability

In the last decade, smartphones have become our daily life's assistants and mobile applications support us in a variety of everyday tasks. In the context of environmental sustainability, Pitt et al. (2011) highlight the unique characteristics of smartphones and their apps to foster pro-environmental behaviors; "smartphones make 'green' information available at everybody's fingertips" (p. 28), which enables users to access green information irrespective from time and location and helps them to integrate "green behavior" in their daily lives more quickly. Brauer et al. (2016) provide a classification of existing sustainable mobile apps and discuss the importance of user goals for user engagement. While sustainable apps exist for various application domains (e.g., lifestyle, mobility, water, waste, energy, wildlife), the focus of prior research seems to be on individual mobility (Froehlich et al., 2009; Tulusan et al., 2012). Schrammel et al. (2015), for example, focus on one specific feature, i.e., (individual and collaborative) challenges as behavior change techniques to support users in engaging in more sustainable travel mode decision and investigate what aspects make users willing to participate in these challenges. In the same vein, Sunio and Schmöcker (2017) reviewed and evaluated existing behavior change support systems (BCSS) designed to promote sustainable travel behavior and emphasized the need to guide users through the process of behavior change by providing concrete recommendations to realize pro-environmental travel behaviors.

2.3 Affordance perspective

Previous research suggests that smartphones and the apps on them offer certain features intended to influence user behavior. However, the material properties of an IT artifact do not determine how people use it and what outcomes emerge. The affordance perspective provides a valuable theoretical lens for theorizing the relationship between technology and its users (Leidner et al., 2018; Volkoff & Strong, 2013). In IS, affordances are the possibilities for action arising from the relation between an IT artifact and a goal-oriented actor (e.g., individual, group, organization) (Volkoff & Strong, 2013). Affordances exist independently of whether the actor perceives them (Volkoff & Strong, 2013). However, to generate outcomes, affordances must be actualized, which requires an actor with the necessary capabilities and a goal served by realizing the action potential (Volkoff & Strong, 2013). Given the differences between actors, the actualization of an affordance is a non-deterministic process, as actors may enact a particular affordance differently, leading to different outcomes. Moreover, affordances can interact with each other in the sense that some affordances can only be actualized after other affordances have been actualized (Leidner et al., 2018). Volkoff and Strong (2013) have emphasized the value of connecting affordances with associated technology features to better understand and conceptualize the IT artifact and to inform the design of IT artifacts. Several IS researchers have empirically investigated affordances in the Green IS domain at an organizational level. Seidel et al. (2013) identify sensemaking affordances and sustainable practicing affordances which facilitate the implementation of sustainable work practices. Building on the sensemaking affordances proposed by Seidel et al. (2013), Henkel et al. (2017) showed how these affordances can support a company's strategic change towards more sustainability. Reuter et al. (2014) identified five functional affordances of IS that assist organizations in reducing energy consumption. While these studies offer valuable insights into Green IS affordances and may help organizations achieve their strategic sustainability goals, the findings do not readily translate to the consumer context since affordances and their actualization are context dependent (i.e., dependent on involved users, their goals, technology, contextual conditions etc.). Since studies at an individual level are rare to date, our goal is to expand existing Green IS research accordingly.

3. Method

Answering our research question "how can mobile technology support individuals to adopt pro-environmental behaviors across different action areas" required us to gain an in-depth understanding of how the use of mobile technology shapes individuals' sustainability behaviors. Given our interest in behavior change, we chose a longitudinal qualitative study design, following the guidelines proposed by Tuthill et al. (2020). This approach allowed us to understand users' experiences, behavioral changes as well as the facilitators or challenges across time. We followed participants forward through time, collecting data at two points in time, rather than relying on retrospective

reports prone to recall bias. Moreover, while primarily using qualitative interviews to collect data, we enriched this data, through quantitative survey data capturing both the ecological footprint of all interviewees, and individual consumption behaviors.

3.1 Research context

We chose *"OneSave/Day"*, a free mobile app available in the English language for Android and iOS users, as our research context. OneSave/Day was launched in September 2021 with the mission "to turn millions of lifestyles into more sustainable ones" (OneSave/Day, 2021). The app is based on the idea that adopting a responsible and sustainable lifestyle is facilitated by daily actions that multiply their impact in a global community. At the time of the study, OneSave/Day's community counted 2.319 registered members mainly from Western Europe and North America. We selected OneSave/Day because it addresses a broad range of pro-environmental behaviors, while previous research mainly focused on one specific area (e.g., travel, energy).

At the heart of the app is the *daily save* feature. App users receive one suggestion every day for a simple action, called "daily save" in the categories water, waste, consumption, energy, mobility, diet, education, or activism (e.g., "Turn off one appliance in your home to save some energy", "Take a shorter shower today - 3 mins max!", "Don't use a plastic cup or water bottle today."). By clicking the button "I do it", the user can signal their commitment to the challenge and see how many other users have done so as well. The challenges are the same for all users. Once the challenge is accepted users can *share* their daily save with their social network, or create a *thank you video* to thank other users for their daily efforts. These activities are rewarded with points. Users can also suggest challenges, which is a participatory design element. Besides the *daily saves*, the app offers additional functionalities, such as a *personal profile* to track individual progress, a *leader board* to compare one' s own performance with the performance of other users, and a *public square* with positive climate news and a forum allowing users to initiate and/or take part in discussions around sustainability issues. In addition, users can activate push notifications to receive a *daily reminder* for sustainable behavior (e.g., "Who is calling? Today's save!"). OneSave/Day represents a technology for environmental sustainability that enables users to break down the challenge of climate change into individual actions. It, therefore, serves as a revelatory research context to explain sustainability behavior at individual level and shows how mobile technologies can support individuals in their long-term goals of a sustainable lifestyle.

3.2 Sampling

Participants in qualitative longitudinal studies are selected based on their shared experience of the phenomenon of interest, while ensuring various points of view (Tuthill et al., 2020). Thus, we decided to include participants who live in the same country (i.e., Germany), in urban areas. To create a common "baseline" (starting point) from which the change of interest begins (Tuthill et al., 2020), we sought individuals who had not used OneSave/Day before. At the same time, we looked for participants of different ages and genders. We recruited all participants through our personal network (Shollo & Galliers, 2016), thus four of the respondents did know each other superficially. We invited individuals who met the criteria stated above, indicated a general interest in sustainability topics, and were willing to download the app OneSave/Day. A total of nine persons participated in the study between March 2022 and May 2022 and agreed to be interviewed at two different points in time and to complete an online questionnaire. Small sample sizes are common in longitudinal qualitative studies (Tuthill et al., 2020). The interviewees were not compensated for their participation in the study and we assured anonymity of each participant. Retention was not an issue with all participants completing the study.

3.3 Data collection

Since we aimed to investigate how sustainability behavior changed over time, we observed our participants over a period of two months. We chose this time period as it allowed users to establish use patterns beyond the initial trial phase and potentially implement behavioral changes in their everyday lives. At the same time, it was short enough to ensure high participant retention (for a similar approach see Schrammel et al., 2015). At the beginning of the study, participants received an e-mail invitation with a survey link and a request to download the app OneSave/Day and create a personal user account to get access to all of its functionalities. No further instructions were provided to create a realistic use scenario in which participants independently determined their interaction with the app. In the survey, participants were asked to answer questions regarding their environmental attitudes and their individual consumption behaviors (e.g., power consumption, diet, mobility). Based on these answers, we were able to calculate the individual ecological footprint using the footprint calculator provided by the "Global

Footprint Network"[1]. At the end of the survey, we thanked the participants for their participation and informed them that we will contact them to schedule an interview appointment. Giving participants the opportunity to become acquainted with the app OneSave/Day, the first interviews were scheduled one week after they finished the survey and downloaded the app. The purpose of these semi-structured initial interviews was to understand the participants' general engagement for sustainability issues and their motivation to use the app, to reflect their expectations toward the app, and to unveil individual objectives of pursuing sustainable behavior (e.g., "What do you do in your everyday life to behave more sustainably?"). After two months, participants were asked in the second interview about their current sustainability activities, frequency and intensity of app use, and challenges they faced when they interacted with the features provided by the app (e.g., "For what purpose did you use the OneSave/Day app?"). All interviews were held in person or via Zoom video call, lasted between 22 and 60 minutes, and were recorded for later transcription and coding.

3.4 Overview of study participants

The sample consisted of 5 female participants (M_{age} = 31.00) and 4 male participants (M_{age} = 33.75) from Germany. All participants have high education levels (Master degree), a relatively high socio-economic status, are full-time white collar workers, and live in cities. With regard to diet, one participant follows a vegan diet, two described themselves as vegetarian/pescatarian, four indicated to be flexitarian and two to be meat eaters. Participants reported their high efforts to save natural resources in their everyday lives, especially water (e.g., turning off water while brushing teeth) and energy (e.g., turning off light, using LEDs), and reduce waste (e.g., no use of plastic bags). Relying on the 7-point Likert scale "personal conservation behavior" (PCB) presented by Milfont and Duckitt (2010), our questionnaire confirmed the self-reported information that participants are already engaged in the conservation of resources (e.g., water, energy, fuel) and implemented behaviors to protect the environment in their daily lives (M_{PCB} = 5.5, Min_{PCB} = 4.2, Max_{PCB} = 6.4). However, the footprint analysis revealed that participants were responsible for an average of 9.9 tons of CO2 emissions per year (Min_{Carbon} = 1.8, Max_{Carbon} = 18.6). In other words, if everyone would live like our participants, we would need on average 3.6 earths (Min_{Earth} = 1.4, Max_{Earth} = 5.2). As the average in Germany is 3.2 earths per individual (compared to 5.0 earths in the US), our sample reflects the reality well and is, therefore, suitable for the aim of our study.

According to the feedback from our participants, they found the app easy to use. Regarding the use of app features, several users stated that the daily reminders (i.e., push notifications) worked as a reminder for them to keep using the app. In contrast, one participant regularly accessed the app due to the public square. Only two participants turned the notifications off after a certain period of time. Overall the daily saves were perceived well by the participants, and a substantial amount of users regularly participated in the challenges. However, there was a subgroup of users (2/9) who stopped taking part in challenges. Reasons were perceived lack of novelty, lack of time in everyday life to implement new activities, and the general intent to spend less time on the smartphone. Besides the daily saves, the public square was positively perceived by the majority of users. Features related to the daily saves were not used intensively. While none of the users shared their participation in the daily saves with their social network or created thank you videos, the leader board was viewed by a few once in a while. Some participants mentioned that social comparison was not relevant for them in the context of sustainability, others underlined that they would prefer to compare themselves with other users they know rather than with strangers.

3.5 Data analysis

To analyze the interview data, we used MAXQDA 2022 provided by VERBI Software and followed qualitative data coding procedures (Miles & Huberman, 1994; Myers, 2020) comprising three steps. In a *first* step, we began our analysis by reading the transcripts in detail to get a first impression of the data. We then used open coding to identify themes, which allowed us to remain open to insights emerging from the data. To identify potential developments in users' perceptions and behaviors, we chronologically analyzed the two interviews of each participant. The coding was done by the authors independently, differences in resulting codes were discussed and resolved. The *second* step focused on affordances by identifying references to the action potentials that emerged from the use of certain features. Hereby, we followed Leidner et al.'s (2018) approach that distinguishes features, goals, arising affordances, and outcomes. We also identified facilitating conditions as well as challenges arising during affordance

[1] https://www.footprintcalculator.org/home

actualization. In this step we also grouped similar codes into aggregated themes. In a *third* step, we linked affordances into strands of affordances and associated outcomes (Leidner et al., 2018). We next compared the results for the different interviewees, identified patterns across the interviewees and aggregated the coding across interviewees.

4. Results

4.1 User motivations and goals of app use

Our participants expressed a variety of motivations for engaging in sustainable behaviors. They perceived climate change was as an urgent issue and expressed concern that it may pose the greatest threat to humanity, as we are unable to assess the plethora of potential environmental consequences and social conflicts triggered by global warming. Some participants discussed their motivation from a more idealistic standpoint, explaining their interest in environmental sustainability with their perceived responsibility for both the society and wildlife, the need for individual social contribution, their desire to lead by example, and to bequeath a livable environment for future generations. In contrast, a subgroup of participants (3/9), mentioned personal benefits associated with pro-environmental behavior (e.g., health benefits when cycling, cost savings on energy & fuel, relaxed train ride). Interestingly, one participant highlighted the trade-off between acting sustainably and not compromising on convenience, whereas another stressed that they would be willing to sacrifice some conveniences. In addition, one participant indicated familiarity with sustainable activities provided by parental education was a motivator for pro-environmental behavior.

In the first interview, participants also stated their goals for using the app OneSave/Day. While some participants mentioned their general interest in technology and their desire to gain knowledge and get new perspectives on environmental sustainability, others aimed to reinforce, and reflect on their existing pro-environmental behaviors. One participant mentioned concrete goals, such as gaining knowledge about waste reduction, conscious consumption (e.g., second-hand shopping) and advice on green mobility. Other participants formulated no particular goals for using the app.

4.2 Affordances and outcomes

In this section, we report the affordances of two features that were used most by the participants and resulted in behavioral and cognitive outcomes: *Daily saves* and *public square*.

4.2.1. Daily saves. Eight participants perceived the daily saves as the key feature provided by the app. They checked the daily saves on a regular basis. Using this feature enabled them to *compare their current behaviors with the ones suggested in the challenge* (Affordance 1). The actualization of this affordance resulted in users either concluding that their current behaviors are in line, leading to *perceived confirmation* (Outcome 1a): *"The things that I have done already were more present and I was more consciously aware of 'Oh, and that's how much I actually do already'."* (female, 30). The other outcome could be a discrepancy, which resulted in *perceived disconfirmation* (Outcome 1b): *„I learned new ways to pay more attention to environmental sustainability, because a lot of things that could be done were not on my radar."* (female, 30).

The outcome of discrepancy led to the affordance of *assessing the feasibility of the suggested behavior* (Affordance 2). This involved individuals' assessing their ability and motivation to perform the suggested behavior. A positive assessment was promoted by enabling factors such as personal relevance or right timing of the proposed challenge. This resulted in *accepting the challenge* (Outcome 2a). In contrast, participants that were overwhelmed by the challenge (e.g., no match with plans of the day, general resistance), did *not accept the challenge* (Outcome 2b): *„There was a suggestion to buy only regional or unpackaged products. I found that difficult, because the range in the grocery store may not be available at all."* (male, 39).

Consequently, a positive evaluation in the second stage opened up the action potential of *enacting new behaviors* (Affordance 3). However, we identified several obstacles that hampered the actualization of this third affordance in some cases such as unexpected change of plans or forgetting the challenge during the course of the day. In case users actualized the affordance, they then evaluated how easy it is for them to implement the new behavior in their everyday life as well as its effectiveness (i.e., whether it provides them the same or even better outcomes). A *positive evaluation* (Outcome 3a) of the enacted behavior resulted in *repeated enactment of the behavior* (Affordance 4) and, thus, in the development of a new routine (Outcome 4): *"There was a challenge to use glass bottles instead of plastic bottles. Since then, I make sure that I don't buy plastic bottles when I go shopping."* (female, 30). In contrast, a *negative evaluation* (outcome 3b), triggered by unintended consequences, and led to the abandonment of the

behavior, so it remained a one-time action. For example, one user mentioned that they participated in the challenge of turning on the eco-mode of the dish washer. While the implementation was easy, the dishes did not turn out clean at the low temperature such that they indicated to refrain from this particular behavior in the future.

Table 1 represents the affordance strand for the daily save feature as well as potential enablers and obstacles for the suggested behaviors.

Table 1. Affordance strand for daily save feature

Affordances	Outcome	Enablers (+) / obstacles (–)
1. Comparing behaviors	(1a) Perceived confirmation (1b) Perceived disconfirmation	
2. Assessing the feasibility	(2a) Accept the challenge (2b) Disregard the challenge	(+) Personal relevance (+) Timing (–) Matching plans (–) Resistance
3. Enacting new behaviors	(3a) Positive evaluation (3b) Negative evaluation	(–) Changed plans (–) Forgetting the challenge
4. Repeated enactment of the behavior	Development of a new routine	(+) Ease of implementation (+) Effectiveness (–) Unintended consequences

4.2.2. Public square. One participant regularly read the information provided in the public square. Using this feature allowed them to *reflect on their behavior* (Affordance 1) and get inspiration for potential pro-environmental behaviors. As a result, they *sought for further information* (Outcome 1) online (i.e., outside the app) on specific topics that were covered in the public square. The interest in these specific topics, as well as personal relevance and easily accessible online information facilitated the search for information. This resulted in identifying *particular areas for improvement* (Affordance 2), which were *implemented in their routines* (Outcome 2). This transition was facilitated by the high perceived impact of the identified behavioral changes as well as the ease of implementation (i.e., effortless, affordable, and availability of options).

For example, in this concrete case the user reflected on their grocery and cosmetics consumption, both topics of high personal relevance: *"The cosmetics and food thing inspired me to look into it further and get more information and ultimately implement changes."* (female, 39) After an online search on sustainable grocery shopping and available green cosmetics products, the user identified the local farmers market that was located near their partner's office and reusable cotton pads as green alternatives: *"I thought, I can change something here and that is possible for me with reasonable effort."* (female, 39) They made buying reusable cotton pads and weekly shopping at the farmers market a part of their adjusted consumption routine. Table 2 summarizes the identified affordances and discussed enablers.

Table 2. Affordance strand for public square feature

Affordances	Outcome	Enablers (+)
1. Reflecting behavior	Information search	(+) Interest in presented topics (+) Personal relevance (+) Easily accessible online information
2. Identifying improvement areas	Implementation of behavior in own routines	(+) High perceived impact (+) Ease of implementation

5. Discussion

Given the pressing issue of climate change, understanding how technologies such as mobile apps influence individuals' pro-environmental behaviors is of significant theoretical and practical importance. In the following, we first discuss our findings in relation to research on Green IS affordances and then mobile technology research.

5.1 Contributions and research implications

This study extends research on Green IS by contributing to the growing body of literature investigating pro-environmental behavior at the individual level. The results of our study support the idea that individuals are, in general, willing to change

their behavior in a more sustainable direction, however, they often need an impetus that facilitates the development of sustainable behavioral patterns (Tiefenbeck et al., 2018).

Our findings support the notion that reducing the complexity of environmental sustainability into simple tasks supports people to engage in ecologically responsible behaviors (Corbett, 2013a). However, our results show that behavior change does not require a system to apply multiple behavior change techniques, as proposed by Corbett (2013a). In fact, we show that also specific features (e.g., challenges) can be effective. This is in line with the findings of Tiefenbeck et al. (2018), who showed the effectiveness of feedback in reducing energy consumption. In addition, our study extends recent research on challenges as a behavior change technique. In line with Schrammel et al. (2015), we found that most participants liked the challenges because of their potential to raise awareness of sustainability in the participants' daily life and guide them towards pro-environmental behaviors. The impulses given by the challenges were further described as a support to participants. Due to the impulses triggered by the challenges, participants felt encouraged to rethink existing behavioral patterns. While Schrammel et al. (2015) focused on users' motivation to participate in challenges, our study goes a step further by uncovering the affordances associated with the challenge feature and explain how they can led to behavioral change. While we show that the challenge feature can provide the affordances necessary to result in behavior change, we also identified several obstacles that hindered users to actualize the full strand of affordances. Future research should investigate ways to overcome these obstacles, for example, by aligning the challenges with individuals' current behaviors, emphasizing the need to act, making the impact of adjusted behaviors transparent, or matching the challenges with individuals' daily routines.

Beyond that, our study demonstrates that individuals can be mobilized to mitigate climate change by simultaneously implementing pro-environmental patterns across various action areas. We thereby extend prior studies that have focused on particular areas such as energy reduction (Loock et al., 2013) and mobility (Froehlich et al., 2009; Schrammel et al., 2015; Tulusan et al., 2012).

We further contribute to literature on Green IS affordances by investigating affordances at an individual level and by focusing on the affordances provided by specific features of a mobile app. As part of sensemaking affordances, Seidel et al. (2013, p. 1282) identified reflective disclosure as an important factor in enabling the establishment of sustainable work practices in organizations. Reflective disclosure affordances "allow for a reconsideration of belief formation, action formation, and outcome assessment". Our findings support the importance of reflection for behavior change also at an individual level. However, we also show that to arrive at behavior change a number of additional affordances must be actualized.

5.2 Practical implications

Our findings provide valuable insights for providers of Green IS and policy makers. Based on our findings, we derive several recommendations.

First, with regard to *daily saves* (i.e., challenges), we suggest that personalization would be beneficial. Better aligning the challenges with users' existing behaviors, goals, context, and everyday routines might be a suitable approach to increase participant and affordance actualization.

Second, accomplishment of behavior change depends on the current pro-environmental behaviors. Therefore, setting the right level of difficulty is important, as users tend to perceive challenges that ask them to perform already habitualized behaviors (e.g., turning off the water while brushing teeth) as trivial and not engaging. On the other hand, if users evaluate the challenges feasibility as low, users do not accept it. Moreover, users should be provided with more support to adopt new and more effortful behaviors.

Third, we found that users' motivation to perform the suggested behavior increases the chance of accepting the challenge and performing the related behavior. Currently, the suggested behaviors are predominantly determined by the app designers. Allowing users to set their own goals (e.g., food waste reduction) and confronting them with related challenges might increase the effectiveness. Moreover, the app could support users in setting a goal that is both relevant to them and also has a substantial impact.

Fourth, assessing whether a challenge is feasible also depends on the individuals living conditions and their daily routines. Thus, the challenges need to be adapted to the users' context as environmentally friendly options differs depending on where they live (country, rural/urban) as well as how their daily lives looks like (e.g., adapting the timing of the prompt). A useful approach might be to permit users to postpone challenges so that they can better integrate them into their lives (Schrammel et al., 2015).

Fifth, we showed that even though users committed to a challenge they sometimes forgot about

it in the course of the day. Sending a reminder could be a potential design solution.

With regard to, the feature *public square*, we found that it affords users to reflect on their own behavior. However, reaching behavior change takes a lot of own initiative (e.g., reading up on certain topics). Providing novel and insightful articles on the platform, rather than only short news, or linking to suitable articles on the web, which provide concrete guidance, could encourage more users to deepen their knowledge and translate knowledge into action. Moreover, a better integration between the daily save and the public square feature may also be beneficial.

While we found that an app like OneSave/Day can indeed influence people to adopt more pro-environmental behaviors, it also underlines the need for policy makers to create the necessary facilitating conditions (Moran et al., 2020). A critical factor for people to engage in pro-environmental behaviors is the availability of options (e.g., green energy, local/regional products) to make it as easy as possible. Under such conditions, mobile apps can serve as a valuable trigger for behavior change. However, while mobile apps can lead to incremental changes of individual behavior, we require systemic change to meet the climate goals in time.

5.3 Limitations and future research

The implications of our study need to be interpreted in light of its limitations. First of all, this study was conducted with a small sample of participants with certain characteristics and backgrounds. To increase the generalizability of our results, we encourage future research with a larger and more diverse sample in terms of e.g., demographics, background, motivation, and initial sustainability behaviors. Moreover, future studies should investigate how users behave differently under the influence of culture as well as context (e.g., availability of environmentally friendly options, social norms, laws, policies). Second, while our study design (i.e., pre-post comparison) allowed us to investigate intervention-induced behavior change over time, we could not control for other factors that also changed at the same time as the intervention was implemented. Therefore, we cannot prove causation between users' exposure to the mobile app and behavioral outcomes, nor can we provide evidence of lasting behavioral impact. In order to underpin the results of this study, future research should extend the study period and ideally apply a randomized controlled trial, including a control group. Third, as our methods relied on self-reports it is possible that our participants were not completely open about their sustainability behaviors, a topic susceptible to social desirability bias. However, we had the impression that our participants were generally very self-critical and usually had no problem admitting to unsustainable behavior. Future research could quantify the observed behavioral changes to provide more accurate information about the magnitude and impact of the changes.

6. References

Brauer, B., Ebermann, C., Hildebrandt, B., Remané, G., & and Kolbe, L. (2016). Green by the app: The contribution of mobile applications to environmental sustainability. In *Pacific Asia Conference on Information Systems 2016 proceedings.*

Corbett, J. (2013a). Designing and Using Carbon Management Systems to Promote Ecologically Responsible Behaviors. *Journal of the Association for Information Systems*, *14*(7), 339–378.

Corbett, J. (2013b). Using information systems to improve energy efficiency: Do smart meters make a difference? *Information Systems Frontiers*, *15*(5), 747–760.

Dedrick, J. (2010). Green IS: Concepts and Issues for Information Systems Research. *Communications of the Association for Information Systems*, *27*(11), 173–184.

El Idrissi, S. C., & Corbett, J. (2016). Green IS Research: A Modernity Perspective. *Communications of the Association for Information Systems*, *38*, 596–623.

Elliot (2011). Transdisciplinary Perspectives on Environmental Sustainability: A Resource Base and Framework for IT-Enabled Business Transformation. *MIS Quarterly*, *35*(1), 197.

Froehlich, J., Dillahunt, T., Klasnja, P., Mankoff, J., Consolvo, S., Harrison, B., & Landay, J. A. (2009). UbiGreen: Investigating a Mobile Tool for Tracking and Supporting Green Transportation Habits. *Proceedings of the SIGCHI Conference*, 1043–1052.

Hedman, J., & Henningsson, S. (2016). Developing ecological sustainability: a green IS response model. *Information Systems Journal*, *26*(3), 259–287.

Henkel, C., Seidler, A.-R., Kranz, J. J., & Fiedler, M. (2017). How to become a Sustainability Leader? The Role of IS Affordances in Enabling and Triggering Sustainability Transformations. *38th International Conference on Information Systems*.

Lehrer, C., Eseryel, U. Y., Rieder, A., & Jung, R. (2021). Behavior change through wearables: the interplay between self-leadership and IT-based leadership. *Electronic Markets*, *31*(4), 747–764.

Leidner, D. E., Gonzalez, E., & Koch, H. (2018). An affordance perspective of enterprise social media

and organizational socialization. *The Journal of Strategic Information Systems*, *27*(2), 117–138.
Loeser, F., Recker, J., vom Brocke, J., Molla, A., & Zarnekow, R. (2017). How IT executives create organizational benefits by translating environmental strategies into Green IS initiatives. *Information Systems Journal*, *27*(4), 503–553.
Loock, C.-M., Staake, T., & Thiesse, F. (2013). Motivating Energy-Efficient Behavior with Green IS: An Investigation of Goal Setting and the Role of Defaults. *MIS Quarterly*, *37*(4), 1313–1332.
Melville (2010). Information Systems Innovation for Environmental Sustainability. *MIS Quarterly*, *34*(1), 1–21.
Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An extended sourcebook* (Second edition). Sage Publishing.
Milfont, T. L., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, *30*(1), 80–94.
Moran, D., Wood, R., Hertwich, E., Mattson, K., Rodriguez, J. F. D., Schanes, K., & Barrett, J. (2020). Quantifying the potential for consumer-oriented policy to reduce European and foreign carbon emissions. *Climate Policy*, *20*(1), 28-38.
Myers, M. D. (2020). *Qualitative research in business and management* (Third edition). Sage Publishing.
OneSave/Day. (2021). *Our Story: This is how it all began*. https://www.onesaveaday.org/our-story
Pan, S. L., Carter, L., Tim, Y., & Sandeep, M. S. (2022). Digital sustainability, climate change, and information systems solutions: Opportunities for future research. *International Journal of Information Management*, *63*, 102444.
Pitt, L. F., Parent, M., Junglas, I., Chan, A., & Spyropoulou, S. (2011). Integrating the smartphone into a sound environmental information systems strategy: Principles, practices and a research agenda. *The Journal of Strategic Information Systems*, *20*(1), 27–37.
Reuter, N., Vakulenko, S., vom Brocke, J., Debortoli, S., & Müller, O. (2014). Identifying the role of information systems in achieving energy-related environmental sustainability using text mining. *22th European Conference on Information Systems*.
Schrammel, J., Prost, S., Mattheiss, E., & Bothos, E. (2015). Using Individual and Collaborative Challenges in Behavior Change Support Systems: Findings from a Two-Month Field Trial of a Trip Planner Application. *International Conference on Persuasive Technology*, 160–171.
Seidel, S., Recker, J., & vom Brocke, J. (2013). Sensemaking and Sustainable Practicing: Functional Affordances of Information Systems in Green Transformations. *MIS Quarterly*, *37*(4), 1275–1299.
Shollo, A., & Galliers, R. D. (2016). Towards an understanding of the role of business intelligence systems in organisational knowing. *Information Systems Journal*, *26*(4), 339–367.
Sunio, V., & Schmöcker, J.-D. (2017). Can we promote sustainable travel behavior through mobile apps? Evaluation and review of evidence. *International Journal of Sustainable Transportation*, *11*(8), 553–566.
Thøgersen, J. (2021). Consumer behavior and climate change: consumers need considerable assistance. *Current Opinion in Behavioral Sciences*, *42*, 9–14.
Tiefenbeck, V., Goette, L., Degen, K., Tasic, V., Fleisch, E., Lalive, R., & Staake, T. (2018). Overcoming Salience Bias: How Real-Time Feedback Fosters Resource Conservation. *Management Science*, *64*(3), 1458–1476.
Tim, Y., Pan, S. L., Bahri, S., & Fauzi, A. (2018). Digitally enabled affordances for community-driven environmental movement in rural Malaysia. *Information Systems Journal*, *28*(1), 48–75.
Tulusan, J., Staake, T., & Fleisch, E. (2012). Providing eco-driving feedback to corporate car drivers. In A. K. Dey, H.-H. Chu, & G. Hayes (Chairs), *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*, Pittsburgh, Pennsylvania.
Tuthill, E. L., Maltby, A. E., DiClemente, K., & Pellowski, J. A. (2020). Longitudinal Qualitative Methods in Health Behavior and Nursing Research: Assumptions, Design, Analysis and Lessons Learned. *International Journal of Qualitative Methods*, *19*(1), 1–21.
Paris Agreement, 2015. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
Volkoff, O., & Strong, D. M. (2013). Critical Realism and Affordances: Theorizing IT-Associated Organizational Change Processes. *MIS Quarterly*, *37*(3), 819–834.
vom Brocke, J., Watson, R. T., Dwyer, C., Elliot, S., & Melville, N. (2013). Green Information Systems: Directives for the IS Discipline. *Communications of the Association for Information Systems*, *33*(30), 509–520.
Watson, Boudreau, & Chen (2010). Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community. *MIS Quarterly*, *34*(1), 23–38.
Weiss, M., Loock, C.-M., Staake, T., Mattern, F., & Fleisch, E. (2012). Evaluating Mobile Phones as Energy Consumption Feedback Devices. In P. Sénac, M. Ott, & A. Seneviratne (Eds.), *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering. Mobile and Ubiquitous Systems: Computing, Networking, and Services* (Vol. 73, pp. 63–77).
World Meteorological Organization (2022). State of the Global Climate 2021. *WMO Publications*, *No. 1290*. https://library.wmo.int/doc_num.php?explnum_id=11178