THE ROLE OF SELF-SET GOALS IN IS-ENABLED BEHAVIOR CHANGE

Research Paper

Wörner, Anselma, ETH Zurich, Switzerland, awoerner@ethz.ch

Tiefenbeck, Verena, ETH Zurich, Switzerland, vtiefenbeck@ethz.ch

Abstract

IS-enabled feedback interventions and self-tracking devices have shown to successfully induce behavior change in various professional and private domains. However, in particular for private contexts, the mechanisms that govern these processes are not well understood. Based on goal-setting theory, we identify self-set goals as a potential driver of behavior change induced by IS-enabled feedback. In a two-month field study, we provide activity-specific real-time feedback on resource consumption to 413 households and study the formation of self-set resource conservation goals in response. We chose showering as an example of an energy-intensive, habitual low-involvement target activity. The results suggest that IS-enabled real-time feedback successfully induces most individuals to set themselves a goal without exhortation, even for this kind of low-involvement activity. Against the predictions of goal-setting theory, we find that individuals tend to set themselves ambitious goals. In line with goal-setting theory, individuals who set themselves ambitious goals conserve more resources. Given the difficulty of defining adequate goals externally, and the risk of goal rejection and adverse reactions associated with externally assigned goals, the results suggest that personal IS should encourage users to self-set goals.

Keywords: Personal IS, Human Behavior, Goal Setting, Self-Tracking, Feedback, Green IS.

1 Introduction

In our lives, we are increasingly surrounded by sensors and connected devices that measure our everyday activities like how many steps we take a day, how we commute to work, or how much energy we consume. As a result of this data collection, information systems (IS) can increasingly provide feedback to individuals related to their personal activities (Hermsen et al. 2016; Swan 2012).

Feedback (providing individuals with information regarding their actions/performance) has proven to be successful in changing individual behavior, not only in work-related contexts, but even in private contexts (Kluger and DeNisi 1996; Moon and Sproull 2008). In particular for habitual or "low-involvement" activities, which individuals perform in their everyday lives without extensive deliberation (Loock, Staake, and Thiesse 2013), studies in various areas provide evidence that individuals respond to feedback, including feedback on physical activity (Bravata et al. 2007) or energy consumption (Abrahamse et al. 2005; Allcott 2011). With the ubiquity of smartphones and other personal IS, feedback interventions are nowadays scalable to large groups of people and can be integrated into their everyday lives easily (Consolvo, Mcdonald, and Landay 2009; Hermsen et al. 2016; Saha and Mukherjee 2003). A growing number of studies have evaluated the effect size of IS-enabled feedback interventions in the real world (e.g., Hermsen et al. 2016; Loock, Staake, and Thiesse 2013). However, several scholars point out that research on the drivers of effective use of IS-enabled feedback is still sparse (Burton-Jones and Grange 2013; Sjöklint et al. 2015).

On the other hand, a vast body of literature in social psychology and behavioral economics has studied personal motivation and behavior change. And integrating the principles and insights of those fields can be beneficial to the IS discipline (Goes 2013). One of the key mechanisms governing behavior is goal setting. After a "35-year Odyssey" of empirical research on goal setting, Locke and Latham (2002) attribute motivation for actions largely to task-related goals. They argue that virtually "all action is the result of cognition and motivation" (p. 707) and can thus be influenced by goal setting. Yet, the majority of their insights is based on laboratory experiments, not on observable outcomes in the real world. This article makes an attempt to link behavior change in the real world, induced by personal IS, to the existing knowledge on goal-setting theory.

In many situations, individuals set goals by themselves: They strive to run a marathon in less than three hours (Allen et al. 2016), make an effort to attain a certain grade (Levy and Baumgardner 1991), or define a specific body weight they want to achieve or maintain (Lupton 2014). Goals can also be successful if assigned by an external party like a principal (Latham and Locke 1991), or a software artefact (McCalley and Midden 2002). While the motivational effect of assigned goals has been observed in many different settings, they can also be rejected or even backfire if applied in a wrong manner (Locke and Latham 2002; Ordóñez et al. 2009). Several scholars emphasize that assigned goals can create unexpected, adverse reactions if they are not suited for the individual and suggest that future research should test goal-setting theory not only in the lab, but especially in natural settings (Loock, Staake, and Thiesse 2013; Lupton 2014; Ordóñez et al. 2009). One difficulty with assigning goals is how to define appropriate ones. Given individuals' heterogeneous preferences and living contexts, they may themselves be best qualified to judge their specific situations and capabilities (Hinsz, Kalnbach, and Lorentz 1997). Moreover, although externally assigned goals have proven to be efficient in organizational contexts (Locke and Latham 2002), they may be perceived as intrusive in private activities such as consumer choice (Camerer et al. 2003).

This raises the question whether in the design of feedback technologies it is necessary to specify and communicate goals (e.g., 10,000 steps per day), or whether users will formulate adequate goals by themselves even for habitual activities when exposed to feedback on their behavior. More generally: *Does IS-enabled feedback prompt individuals to self-set goals for the measured behavior by themselves and if so, is there a relationship between the difficulty of the self-set goals and the measured behavior?*

To answer this question, we seek to understand the goal-setting behavior of individuals in response to detailed IS-enabled real-time feedback on a habitual activity. In a framed field experiment with 413 participating households, we examine whether *individuals set goals by themselves; how ambitious these goals are; and what effect they have.* To that end, we chose a feedback application from the domain of residential energy consumption, more precisely a personal IS displaying real-time feedback on the resource consumption of the ongoing shower. We chose that particular activity for four reasons: a) showering is an energy-intensive daily behavior that accounts for 12-16% of residential energy use (Bertrand et al. 2017), b) the amount of energy and water consumed is largely influenced by the individual's daily decision-making (unlike the energy use of most appliances, which is largely determined by technical characteristics), c) it is a low-involvement activity (Loock, Staake, and Thiesse 2013), and d) it is an activity (typically) carried out by an individual in isolation who is not being monitored by others and which is not subject to clear social norms (e.g., how many liters of water or kWh of energy would be considered as a "normal" shower).

The article is structured as follows: We first present related literature on IS-enabled feedback interventions and on goal-setting theory along with our hypotheses, followed by a description of the experimental design and results. The article closes with a discussion of these results and implications for future research.

2 Related Work

2.1 Feedback and Personal Information Systems

Feedback interventions have proven to successfully induce behavior change with and without the use of personal IS in a variety of different applications. In the context of resource consumption, Allcott (2011) analyzes a series of programs in which households receive periodic Home Energy Reports that compare their electricity consumption to similar homes in the neighborhood. The author shows that the program cost (dollars per kWh saved) is substantially lower than the marginal cost of electricity production, which implies that these programs yield net benefits, not costs. Abrahamse et al. (2005) conduct a meta-study of over thirty experiments on different behavioral interventions for resource conservation. They find that feedback is effective in most cases, yielding resource savings of 2-28%, depending on the setting, yet the drivers of the observed behavior change are unclear. Other applications of feedback interventions include health, nutrition and transportation behavior. For instance, Vandelanotte et al. (2005) and Bravata et al. (2007) find that feedback improves nutrition behavior and physical activity and is most effective if the information is personalized. Froehlich et al. (2009) create an application that provides visual feedback on transportation behavior and find evidence that participants' subsequent transportation behavior is more eco-friendly.

While all of the aforementioned studies report positive results for feedback interventions, the observed effect sizes vary with the target activity, the general setting, and the way feedback is presented (Kluger and DeNisi 1996). A key finding is that in particular for habitual activities, the more closely (in time and place) the feedback is linked to a particular target activity, the better (Ehrhardt-Martinez et al. 2010; Froehlich, Findlater, and Landay 2010). This emphasizes the importance of the medium by which the intervention is provided; ideally, it should be accessible during the targeted activity and process information in real time (Tiefenbeck et al. 2016). Personal IS increasingly make this possible at population level: With the ubiquity of smartphones, sensors, and networks, IS-enabled behavioral interventions offer more and more possibilities to deliver personalized feedback (Froehlich, Findlater, and Landay 2010; Hermsen et al. 2016).

Li et al. (2010) define personal IS as systems that "help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge" and state that these systems thus support individuals' insightful reflection. In this way, the activity feedback provided by smart devices can influence individuals' behavior in habitual activities. This phenomenon is called "self-tracking", "quantified self", or "living by numbers" (Consolvo, Mcdonald, and Landay 2009; Li, Dey, and Forlizzi

2010; Lupton 2014). As an example, according to Fox and Duggan (2012), already in 2012, 19% of the smartphone owners in the US had downloaded an app to specifically track their health.

As Swan (2012) states, the overarching goal of such continuous monitoring and immediate feedback enabled by connected devices is lasting behavior change. Technical advances enable the cost-effective provision of behavioral interventions to large and diverse groups of people at virtually any place in real time (Saha and Mukherjee 2003; Swan 2012). Still, although many self-tracking devices aim at enabling the user to change her behavior in a desired way (Sjöklint et al. 2015), a profound understanding of the motivations and effects on the user is missing (Gimpel, Nißen, and Görlitz 2013). Most of the feedback studies presented above do not discuss the motivation or personal incentives for users to change their behavior once they are presented with IS-enabled feedback. Based on a meta-study on digital technologies for disrupting and changing behavior, Hermsen et al. (2016) conclude that more research should study the factors that drive and sustain behavioral effects in order to design more effective IS.

Sjöklint et al. (2015) argue that personal IS providing personalized feedback can represent an "instrument supporting the user's willpower to reach a specific daily goal". They conduct an explorative study on wearable devices based on semi-structured interviews and identify activity-specific goals, partly assigned and partly self-set, as motivators to change undesired habits. Yet, several interview participants stated that that they used the feedback merely to learn about themselves and not to actually change their behavior, or that the goals assigned by the devices were inadequate or undesirable.

2.2 Goal Setting

The impact of goals on performance has been studied by psychologists and behavioral economists for decades. The founding fathers of the empirically based "goal-setting theory" that integrates insights from both disciplines are Edwin Locke and Gary Latham. While they have focused on goals and performance in work-related tasks (Locke and Latham 2002), their studies are so extensive that many findings can be transferred to private settings (Locke 1996). Goals can be defined "as the object or aim of an action" (Locke 1996, p. 181), or as "internal standards that specify the conditional requirements for positive self-evaluation, which provides incentive for action" (Williams et al. 2000, p. 161).

According to goal-setting theory, goals regulate behavior by representing a conscious reference point that guides subsequent activities (Locke and Latham 2006). They serve as motivators because the achievement of a goal leads to satisfaction of the individual, whereas goal failure leads to dissatisfaction (Locke 1996). Outcomes of an activity are thus evaluated as gains or losses against that reference point. In behavioral economics, a reference point can be formally represented as a jump or discontinuity in an individual's utility function; or as kink or discontinuity in the first or the second derivative of the utility function, depending on the model (Allen et al. 2016; Kahneman 1992; Kahneman and Tversky 1979). This implies that satisfaction and dissatisfaction are typically perceived unsymmetrically: Failing a goal has a qualitatively stronger effect than achieving it. This gives theoretical support for the motivational power of goals, as it disproportionally increases the gain from achieving a goal compared to just missing it. In psychological terminology, the interpretation as reference point translates to: Goals involve discrepancy production ("feedforward control", i.e. initial motivation by setting goals above current levels) and discrepancy reduction ("feedback control", i.e. adjustments of effort to achieve desired goal) (Williams, Donovan, and Dodge 2000). For this mechanism to work, explicit feedback showing progress on task-performance is crucial (Kluger and DeNisi 1996; Locke 1996).

Key moderators of goal setting are thus task complexity, situational constraints, commitment to a goal and task-related feedback (Locke and Latham 2006). In many daily activities in private settings, task complexity is low and situational constraints often cannot be circumvented for practical reasons. As there is no external control mechanism to incite commitment, the individual's own commitment to the goal is critical. Gaining this commitment is easier for self-set goals (Hinsz, Kalnbach, and Lorentz 1997; Locke 1996), as they have been chosen willingly and consciously by the individual. Moreover, self-set goals do not run the risk of being rejected for being too difficult. Ordóñez et al. (2009) even

suggest that assigned goals can "go wild" and create unexpected adverse reactions, for example if the same goal is applied to a set of different people and does not match the individual situation. This may explain why self-set goals have been more successful than assigned ones in some experiments involving private activities: In a series of lab experiments, McCalley and Midden (2002) provided feedback to n=100 participants on the energy consumption of simulated washing cycles. The authors find that participants who were explicitly prompted to self-set a goal by typing it into a user interface consumed less energy than both, participants who were not asked to set a goal and those who were assigned a fixed one. In a field study with 1,791 participants, Loock et al. (2013) presented subjects with smart meter readings of their household energy consumption. While some (randomly assigned) subjects were asked to freely set a goal for their energy consumption, others received a predefined default goal. The results indicate that default goals can have positive and negative influence on individual behavior, depending on goal difficulty; medium-level default goals are most effective, whereas too low or too high defaults are outperformed by self-set goals. *In addition to being efficient, self-set goals do not have to be derived in a complicated manner, but are often chosen by the individual by herself* (Locke 1996, p. 120)*:* "When provided with feedback on their own performance or that of others, people often spontaneously set goals to improve over their previous best or beat the performance of others simply as a way of challenging themselves [...] The effect of performance feedback (knowledge of score) depends on the goals set in response to it." However, (Locke 1996) states that one possible downfall is that individuals who self-set goals may choose less ambitious, easier-to-reach goals than goals that are assigned by a third party.

2.3 Research Gap & Hypotheses Development

Although goals have been shown to be important motivators of human behavior, the role of implicit, self-set goals as motivators for behavior change is not well understood yet, especially in the context of IS-enabled feedback that enables constant self-tracking (Sjöklint et al. 2015). It is not clear whether personal IS can best support the desired behavior change by deriving and displaying explicit goals for the user or whether individuals will set a goal by themselves that is "adequate" (ambitious, but achievable) in their specific situation in response to IS-enabled feedback. If the latter is the case, then IS should not assign explicit goals, to avoid adverse reactions (e.g., of individuals rejecting an assigned goal they perceive as too ambitious or as too easy to reach in their particular situation).

Therefore, this article aims to understand which role self-set goals play in the behavior change triggered by activity-specific real-time feedback provided by personal IS. More precisely, we will develop five hypotheses to understand whether individuals set goals by themselves (H1), whether self-set goals are ambitious (H2, H3), and what is the relationship between self-set goals and actual energy savings (H4, H5). Our hypotheses apply knowledge from goal-setting theory and previous studies to IS-enabled behavioral interventions. The study is placed in the context of a low-involvement behavior which users typically are not highly interested in. We investigate the hypotheses in a setting in which individuals receive real-time feedback on their resource consumption (water and energy) in the shower. First, we investigate whether individuals choose a goal by themselves without being nudged to when presented with consumption feedback, as suggested by Locke (1996) and Hermsen et al. (2016):

> *H1: When exposed to real-time feedback on their resource consumption, individuals are likely to choose a conservation goal by themselves.*

After having established whether individuals choose self-set goals when exposed to real-time feedback on their resource consumption, we examine the difficulty of those goals. As described earlier, self-set goals have several advantages over externally set goals: They do not have to be derived by a second party for every individual and they do not run the risk of being rejected for being inappropriate or too difficult. Yet, the disadvantage commonly brought forward is that self-set goals will not be ambitious enough, as Locke (1996) argues that individuals will choose their self-set goals below what they could actually reach. Since goal failure creates dissatisfaction, a tendency to choose goals which are easily achievable seems intuitive. Based on this, we hypothesize that individuals will not choose ambitious

goals. As it is hard to define what is 'ambitious' in our context, we will analyze goal attainment as a (negative) proxy for goal difficulty:

H2: Individuals' self-set conservation goals are not too ambitious, i.e. they reach them most of the time.

As several studies discuss whether gender plays a role in goal-directed behavior, we also examine whether we can find a difference among genders. For instance, Venkatesh, Morris, and Smith (2000) present several arguments suggesting that men are more motivated by needs of achievement and more directed towards goals than women. Likewise, Levy and Baumgardner (1991) show in an experimental study that men choose more ambitious goals than women. Based on this literature we hypothesize:

H3: Men choose more ambitious conservation goals than women.

Finally and most importantly, we examine the relationship between goal setting and resource conservation (i.e. task performance in the present setting). In line with the theoretical explanations for the motivational effect of goals presented earlier (Allen et al. 2016; Locke and Latham 2002; Sjöklint et al. 2015), and empirical studies on the provision of goals for resource conservation (Loock et al. 2013; McCalley and Midden 2002), we conjecture:

H4: Individuals who set a conservation goal for themselves consume less resources during the intervention phase than those who did not.

Finally, Locke and Latham (2002) claim that the higher the goal, the better the individual's task performance. One of the core findings of their work is that there exists a positive linear relationship between goal difficulty and performance. Against this backdrop, we analyze the relationship between goal difficulty and resource conservation:

H5: There is a positive linear relationship between goal difficulty and resource conservation.

3 Methodology

3.1 Experimental Setup

We conducted a two-month framed field experiment in which we targeted showering as a resource-intensive, low-involvement activity. Participants received a smart shower meter, which displayed real-time feedback on their energy and water in the ongoing shower (Figure 1). Participants installed the IS artifact themselves (simple process, no tools required). The device recorded energy and water consumption, average water temperature, interruptions, and duration of each shower. To collect data on the participants' behavior in the absence of feedback, all devices displayed only water temperature during the first ten showers. That period serves as baseline measurement; afterwards, the feedback intervention started. From then on, the device of two thirds of the households displayed energy and water consumption in real time (see Figure 1). A third of the households was assigned to the control group, which served as a reference group: Their shower meter continued to display only water temperature.

Participants were recruited among a sample of 5,919 residential customers of the Swiss utility company ewz who had participated in an electricity smart metering study. Only one- and two-person households were admitted due to technical constraints in the storage capacity of the device. Individuals needed to opt in by filling out an online survey and agree to share their shower data with the researchers. Among the 1,348 households who registered, 700 were chosen on a first-come-first-served basis due to cost and logistics limitations. For further details on the experimental set-up and the randomization checks of the sample of participants, please refer to (Tiefenbeck et al. 2016).

In a pre-experimental survey, participants disclosed socio-demographic information and answered several questions on personality and environmental attitudes. The questions on individuals' personality

factors were based on the HEXACO Personality Inventory (Lee and Ashton 2004) and the questions on environmental attitudes had the same wording and scales as the nationally representative Swiss Environmental Survey (Diekmann et al. 2009). Comparisons to Swiss national statistics and a representative Swiss environmental survey (Diekmann et al. 2009) indicate that our sample is younger, more urban, and more educated, but slightly less (!) environmentally friendly than an average Swiss person.

Among other questions in the pre-experimental survey, participants were asked how often they compared their own performance with others individuals' (five-point Likert-scale, 1 = never, 5 = often) and whether they acted environmentally friendly even if this incurred costs and efforts (1 = do not agree, 5 = agree). After the experiment, participants were asked to fill out a survey that included Likert scales assessing their perception of the shower meter and on their goal-setting behavior. The question regarding goal setting was formulated as follows: *"The smart shower meter displays information on your water and energy consumption since the baseline phase has ended. Have you set yourself a goal per shower that you try not to exceed (e.g., max. water volume or energy efficiency class)?"* The question could by answered by checking yes or now (or "The device still only displays temperature."). Those who responded yes were asked to *specify that goal* in a textbox. A free text field was chosen in order not to prime participants on particular numbers.

Figure 1. Personal IS displaying real-time feedback on resource consumption in the shower.

3.2 Data

A complete dataset (both surveys and shower data for the entire study duration) is available for 621 households. Among these, 208 had been assigned to the control group and 413 to the treatment group. After the experiment, participants in the treatment group received the post-experimental survey with the question on their goal-setting behavior. We will thus focus on these 413 households.

Since participants indicated their goal in a free text field, some of them stated multiple goals or a range, e.g., "30-50 liters". For our analyses, we converted ranges to the mean value, (40 liters in the example), except for the analysis presented in Figure 2, for which we took both the upper and the lower bound, but weighted those responses with 0.5 (otherwise participants who indicated a range would be counted twice). As most of the participants stated a goal related to water consumption in liters, we will focus on water consumption in liters rather than on energy in kWh in the following analyses. In our study, energy consumption can be easily converted to water consumption and vice versa based on the data stored on the device. Given the high correlation between water and energy consumption per shower (0.989), the choice of the unit of analysis does not change the results in any meaningful way. If a participant stated multiple different types of goals, like "below 39 °C and below 50 liters" (which happened in 16 cases), we chose the water volume-related goal or the one that was easiest to convert to water volume (to have one common metric). Whereas the shower data recorded in two-person households include observations from both household members, the survey was completed by one person per household. As a result, answers to questions on attitudes or goals set thus solely reflect the respondent's perspective. Therefore, for data consistency, we excluded 2-person households in the main numerical analyses that involve the shower measurement data, i.e. for the evaluations of hypoth-

eses *H2*, *H4*, and *H5*. The remaining subsample includes 196 individuals and 10,878 measured data points. (For the sake of completeness and as additional sensitivity analysis, we also conducted all analyses with the full sample including the 2-person households; the results are very similar and available on request.)

3.3 Results

The real-time feedback provided by the smart shower meters results in substantial behavior change and resource savings. As soon as the device starts displaying feedback from shower 11 on, resource consumption per shower in the treatment group drops considerably. Overall, participants in the treatment groups reduce their water consumption per shower by 9.5 liters compared to the control group. This amounts to 22% savings both in water and energy consumption; the savings effects are stable over the duration of the study. For a detailed description of the analysis and of the effects induced on consumption behavior, please see (Tiefenbeck et al. 2016). While that first article focuses on the savings effects of the intervention, their stability, and the cost-effectiveness of the intervention, the current article digs deeper into the underlying psychological mechanisms. In particular, we assess whether the large savings were mediated by the participants setting goals for themselves in response to the feedback.

To answer the first hypothesis *(H1),* we evaluate whether the participants set themselves a goal regarding their maximum resource consumption per shower in response to the real-time feedback. Note that they had not been exhorted or encouraged to do so at any point of the study. Based on the post-experimental survey, we find that indeed, 221 of the 413 questionnaire participants confirm that they have set a goal by themselves. We can thus infer: When exposed to real-time feedback on their resource consumption, many individuals (54%) in our sample did indeed set a conservation goal by themselves.

To get a better understanding of the goals individuals chose, Figure 2 depicts the absolute frequency of goals stated as maximum water consumption goal in liters. This subset includes 154 surveys. As the figure illustrates, most participants specified round numbers (i.e., multiples of tens), which is in line with existing studies on self-set goals (Allen et al. 2016). A total of 94 of the 154 liter-goals (61%) were round numbers; overall, 127 goals (83%) were multiples of five, whereas other numbers were hardly ever chosen. The most popular goal was 30 liters, which was chosen by 23 participants.

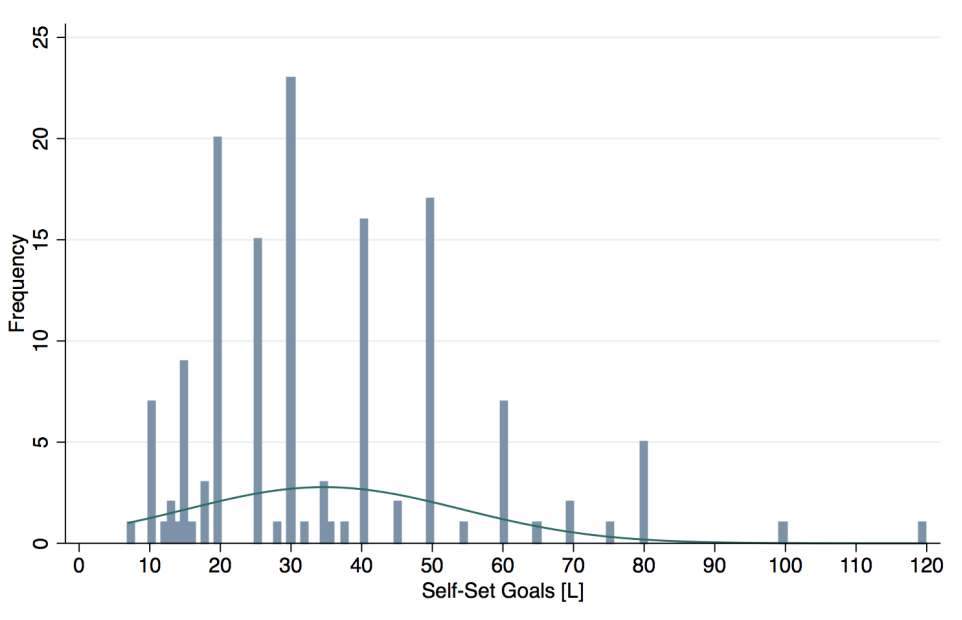

Figure 2. Self-set goals related to water consumption. Participants exhibit a clear propensity for choosing multiples of 10.

We now turn to *H2* to examine how ambitious the self-set goals were. The results show that most individuals chose a goal well below their average water consumption in the baseline period. This is consistent with other studies on resource consumption behavior, which show that individuals try to conserve resources if presented with relevant information (Abrahamse et al. 2005; Allcott 2011). Yet, the relative difficulty of the chosen goals is surprising: On average, people chose a goal 12.1 liters (sd 21.2) below their average baseline consumption, which corresponds to a 20.1% reduction in their water consumption (sd 26.7). Note that the high standard deviation indicates that the goals vary substantially between individuals and that goals were not defined as percentage savings relative to the baseline by the participants, but as absolute value or range they tried not to exceed.

Figure 3 depicts to what extent the participants who stated having set themselves a maximum consumption goal reached that goal. The histogram displays deviations between their self-set goal and their actual resource use in the intervention phase (when the feedback was visible). The subset of observations from those individuals includes 10,878 showers. A negative deviation from zero indicates that the individual used less water than specified in the individual goal, i.e. the individual met her conservation goal. The deviations are roughly normally distributed around the zero marker. Our interpretation of this distribution is that the self-set goals serve as reference points for the users.

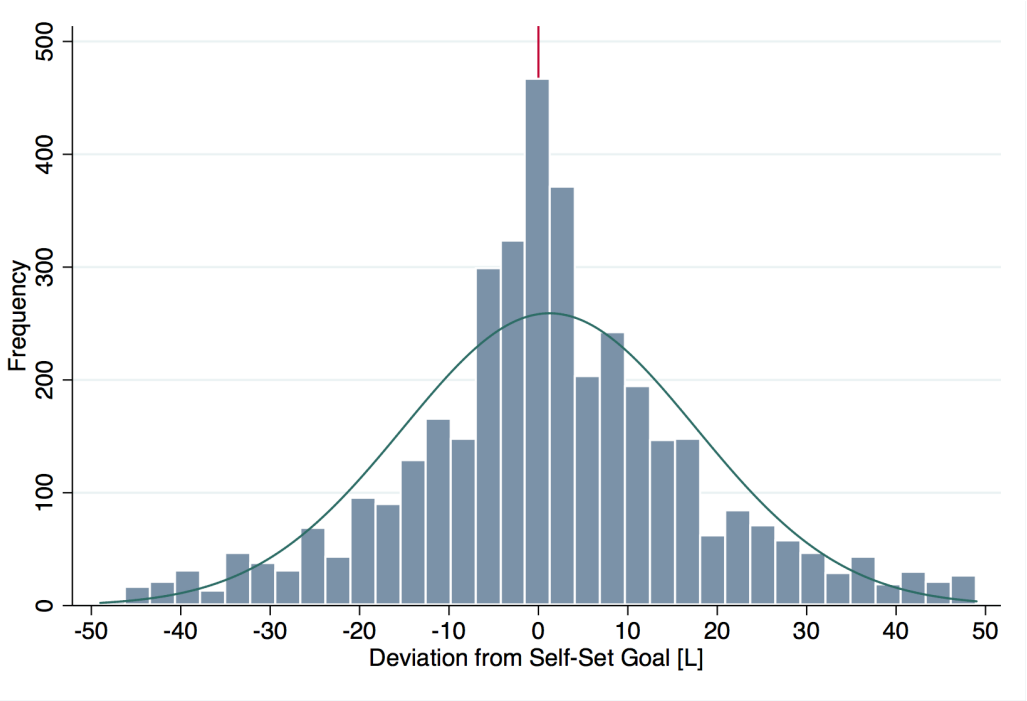

Figure 3. Distribution of deviations from self-set goal. The bulging around (in particular just below) 0 indicates that self-set goals serve as reference points for the individuals.

Still, remarkably, participants on average fail their goal by 2.7 liters (sd 25.3). Thus, we cannot confirm the prediction of *H2* that individuals set themselves unambitious goals which they can achieve easily. This is in clear contradiction to the literature on goal-setting theory in which missing goal difficulty is used as a key argument why goals should be assigned externally, as opposed to encouraging self-set goals. Possible explanations are that situational constraints did not allow for the desired, ambitious conservation, or that the self-set goals were viewed as rough guide rather than as strict limits. For robustness, we reconfirmed that the fact that the average shower does not meet the goal is not biased by outliers: The median deviation is 1 liter above the individual goal and participants fail their self-set goals in 50.2% of the showers.

Regarding *H3* (assessing gender differences in goal difficulty), men on average set goals 22.4% below their baseline water consumption, whereas the average goal reported by women was 16.8% below their baseline water consumption. This difference, however, is not statistically significant (t(90)=-0.67,

p=0.50), so we cannot confirm the hypothesis that men choose more ambitious goals. Moreover, these numbers are confounded by the fact that men in our sample started with a considerably higher average baseline consumption, 48.4 liters (sd 34.6) than women, 40.3 liters (sd 22.5). Previous analyses (Tiefenbeck et al. 2016) show that there is a strong positive interaction between resource conservation and baseline consumption – simply put, it is easier for high consumers to conserve resources.

To deduct practical implications for the design of IS-enabled behavioral interventions, the crucial question is how self-set goals actually affect behavioral outcomes. In other words, did participants who set themselves a goal use less resources than those who did not? We estimate a linear regression model (1) on our sample to test the relationship between self-set goals and resource conservation. Regression analysis is a very established technique in behavioral research (e.g. Loock, Staake, and Thiesse 2013; Moon and Sproull 2008; Venkatesh, Morris, and Ackerman 2000). In this linear regression, dependent variable y_i is water consumption per shower of household *i* in the intervention period. The independent variable x_{1i} is a binary variable indicating whether individual *i* reported a self-set goal (=1) or not (=0). The model controls for baseline consumption x_{bi}, which is the average water use of household *i* during the first ten showers.

$$y_i = \beta_1 x_{1i} + \beta_b x_{bi} + \varepsilon_i \quad (1)$$

The first column in Table 1 shows the regression results for all treatment participants in 1-person households. The average water consumption per shower during the intervention phase was significantly (4.8 liters per shower) lower among those individuals who self-set a goal. Thus, we can confirm *H4*. The numbers also reveal the strong correlation between baseline consumption and savings effects. Mean water consumption during the intervention phase was 37.6 liters (sd 29.2) for participants who chose a goal as opposed to 40.8 liters (sd 40.6) for those who did not. Thus, not only are participants likely to set a goal by themselves, but those who do consume significantly less resources than those who do not *(H4)*.

To evaluate the results for *H5*, the relationship between goal difficulty and conservation, we conduct a second regression. The dependent variable, y_i, in model (2) is again water consumption per shower for household i. As independent variable x_{2i} we now do not consider the binary value of having set a goal or not, but insert goal difficulty in liters. As described above, we define goal difficulty, x_{2i}, for the households who chose a goal by the difference between stated goal and measured baseline consumption in liters.

$$y_i = \beta_2 x_{2i} + \beta_b x_{bi} + \varepsilon_i \quad (2)$$

The results for model (2) can be found in the second column of Table 1. Coefficient β_2=-0.56 is negative and highly significant, which implies that the more ambitious a goal is, the more individuals conserve on average (Table 1, Column 2). Each liter the self-set goal was below the individual baseline consumption yields 0.56 liters in average water conservation per shower. This means that higher goal difficulty increased the conservation effect, so we can confirm *H5*. These findings are in line with one of the key propositions of Locke and Latham (2002), who argue that there is a positive linear relationship between goal difficulty and task performance. Analyses of the consumption medians (instead of means) that we have conducted as robustness checks provide very similar different results.
Note that we do not establish causal relationship in H4 – based on the regression results, it is not possible to say whether self-set goals cause the savings, or whether the kind of individuals who set themselves a goal are also the ones who conserve more resources. Therefore, we assessed confounding effects to evaluate whether individuals who are generally more concerned about the environment were more likely to set themselves a conservation goal and to conserve more resources. If that were the case, then case goal setting might be merely another manifestation of interest in the topic, rather than serve as mediator for behavior change. To evaluate whether goal-setting behavior can be explained by other latent variables collected, like individuals' personality traits, their tendency to compare themselves to others, or environmental awareness, we used the results of the pre-experimental survey to estimate model (3). Column three in Table 1 contains the results of a third regression in which we in-

cluded the same variables as in model (1), but added control variables for the self-reported environmental awareness, tendency to compare oneself to others, and the six HEXACO-dimensions (honesty, emotionality, extraversion, agreeableness, conscientiousness, openness). We do not find any significant influence of these variables on resource conservation, whereas self-set goals and baseline consumption are still highly significant in this extended model. In particular, the estimates for goal-setting are barely affected by environmental attitudes and personality traits. While we cannot entirely rule out that the correlation of resource savings and goal setting is confounded with other, unobserved variables, these results are indicative of self-set goals acting as mediators of resource conservation.

	Model (1)	**Model (2)**	**Model (3)**
Goal set? (0=no, 1=yes)	-4.75** (1.73)	-	-5.11* (1.99)
Goal difficulty, i.e. baseline - goal [L]	-	-0.56*** (0.16)	-
Baseline consumption [L]	0.72*** (0.06)	0.86*** (0.07)	0.68*** (0.09)
Environmental awareness	-	-	-3.13 (1.90)
Tendency to compare oneself to others	-	-	-0.34 (0.94)
Honesty	-	-	0.21 (1.76)
Emotionality	-	-	3.16 (1.85)
Extraversion	-	-	-0.28 (1.67)
Agreeableness	-	-	-0.46 (1.48)
Conscientiousness	-	-	-0.34 (1.74)
Openness	-	-	-0.97 (1.43)
Constant	8.48** (2.58)	-3.71 (2.02)	19.08 (14.07)
R^2	0.76	0.76	0.76
Observations	196	90	153

Table 1. Relationship between goal setting (model 1) / goal difficulty (model 2) and water consumption in liters. Standard errors are in parentheses, adjusted for clustering at the household level. (, ** , and *** indicate significance at the 5%, 1%, and <0.1% levels, respectively.)*

4 Discussion & Conclusion

4.1 Discussion

This paper evaluates goal-setting behavior in response to IS-enabled real-time feedback on the individual's resource consumption in the ongoing shower. As a first result, we find that the majority (54%)

of individuals set a conservation goal by themselves without being exhorted or encouraged to do so in any way. While goal-directed behavior has been studied in the context of various high-involvement activities (Allen et al. 2016; Levy and Baumgardner 1991; Locke and Latham 2002), it is remarkable it also occurs in the context of a low-involvement activity like showering and with respect to the consumption of the low-involvement good energy, which individuals typically show little interest in (Attari 2010). It is important to note that there was no mentioning of the study investigating personal motivation or goal-setting behavior at any previous point in the study, nor any exhortation that participants should set themselves a goal – they simply did so by themselves in response to the feedback intervention. Moreover, we find no significant influence of any of the personality factors that were assessed in the pre-experimental survey on goal setting in analyses that we conducted for completeness.

We also find that individuals chose ambitious conservation goals that they were not able to meet on many occasions. Based on the results for *H2*, the concern raised by Locke (1996) that individuals may not choose ambitious goals by themselves to avoid the negative sensations associated with failure, does not seem warranted in our setting. Moreover, since goal difficulty has a positive impact on conservation in our study (Table 1), goal failure for an ambitious goal can still imply substantial resource conservation, i.e. success of the intervention. Future research should thus investigate whether motivating individuals to choose even more ambitious goals can further increase the effects.

The results on *H4* indicate that individuals who self-set a goal used significantly less water in response to the feedback intervention than those who did not. Moreover, for *H5*, we find a positive correlation of goal difficulty and resource conservation: individuals who set themselves an ambitious goal (far below their resource consumption in the baseline period) exhibit larger conservation effects. It is important to note, however, that our research design does not allow us to establish a cause-effect relationship between self-setting of goals and conservation behavior: It is both conceivable that a) the act of self-setting a goal mediates conservation efforts and the associated savings, as McCalley and Midden (2002) found, or that b) the kind of individuals who self-set a goal were systematically different from those who did not in the first place (in a dimension that we did not assess). If the former is true (i.e., that the act of self-setting a goal induces larger conservation effects by increasing task motivation), then personal IS should actively prompt individuals to set themselves a goal. On the other hand, if the latter applies, then the act of goal-setting could be just another manifestation of the individual's interest and commitment to the conservation task, which at the same time produces larger conservation effects. Thus, we are not able to entirely rule out that the goal-setters in our study exhibited some unobserved characteristic (e.g., general interest in technology or numbers) that caused both the goal-setting and the higher conservation effects among that subset of participants. However, we did not find any evidence that those who set a goal by themselves were more environmentally aware, nor that they had a higher general tendency to compare themselves to others. These results are indicators that self-set goals act as mediators of resource conservation. Further IS-enabled field studies could improve the identification and establishment of a causal relationship by random assignment, whereby one treatment group is systematically prompted to self-set a goal, while another treatment group is not.

4.2 Limitations

Despite our best efforts in the study design, there are some limitations to our results. Participants who indicated in the survey at the end of the study that they had set themselves a maximum consumption goal were asked to state that goal in a free text field. They answered in different metrics, some set multiple goals, and some defined target ranges rather than maximum values. This introduces some blurriness in our data that we cannot fully control for. However, the open way to answer the question enables us to get a more unbiased view of how individuals chose their personal goals.

Wherever possible, we used established validated scales like the HEXACO inventory (Lee and Ashton 2004). In order to compare the environmental attitudes of our sample with the general population, we used the same wording as the Swiss environmental survey (Diekmann et al. 2009). Nevertheless, like any self-reported data, there is a risk of social desirability bias. For the reported self-set goals, it is im-

possible to say whether the participants set their goals at the beginning of the intervention phase or if they adjusted their goals over time, as their task-related knowledge increased. Future research should investigate how self-set goals evolve over time.

One limitation is the fact that participation in our study was voluntary. While we did our best to mitigate those issues by comparing socio-demographic data and environmental attitudes with the general Swiss population, caution may be warranted with the external validity of the results, as in any study with an opt-in sample.

While we have no "baseline" measure whether individuals also had maximum consumption goals for the target behavior prior the feedback intervention, we asked participants how much water they thought they used per shower, both before and after the study. The results indicate that prior to the intervention, most individuals had a poor sense for their actual water consumption, which improved significantly with the intervention (Tiefenbeck et al. 2016). Thus, we do not establish a baseline for goal setting as we cannot not expect individuals to come up with meaningful goals for their shower-related resource consumption by themselves in the absence of the feedback intervention.

Another aspect that should be tackled in future research is a systematic comparison of self-set goals to externally assigned goals. On the one hand, our results suggest that IS-enabled real-time feedback successfully induces many individuals to set themselves ambitious goals even for low-involvement activities, and that individuals who set themselves ambitious goals in response to the feedback intervention conserve more resources. On the other hand, future research should directly compare the impact of self-set and externally assigned goals to determine in which situations which strategy is more effective and in line with individuals' preferences.

4.3 Conclusion

Personal information systems are becoming more and more pervasive and make it possible to reach mass audiences (almost) in real time. The combination of feedback interventions with these technologies has the potential to support individuals in changing their behavior into healthier, more sustainable, or socially desirable habits (Consolvo, Mcdonald, and Landay 2009; Hermsen et al. 2016; Li, Dey, and Forlizzi 2010). It is thus in the interest of society to understand the mechanisms that drive behavior change in response to that kind of increasingly ubiquitous information.

Based on goal-setting theory, we investigate self-set goals as mediators of individual behavior change in response to real-time feedback in the context of a low-involvement activity. Our findings are based on real-world measurement data (over 10.000 observations) from a framed field experiment with 413 participating households. To the best of our knowledge, this is the first field study that investigates the formation of self-set goals in response to IS-enabled feedback. In particular, we find that even in the context of a habitual activity and regarding the consumption of a low-involvement good, many individuals set themselves a goal in response to real-time feedback, without ever being encouraged to do so. Against the predictions of Locke (1996), we find that individuals tend to set themselves ambitious goals that they do not achieve easily. In line with goal-setting theory, we find a positive relationship between goal setting and resource conservation and, in particular, between goal difficulty and resource conservation, meaning the more ambitious the chosen goal is, the more resources are conserved.

Since the majority of participants in our study set a goal by themselves even for the consumption of a low-involvement good like energy, it is likely that most individuals will set themselves goals for other activities tracked by IS as well. Combined with the strong relationship of goal setting and effect size that we find, self-set goals may explain the strong behavioral effects observed for existing self-tracking applications (Consolvo, Mcdonald, and Landay 2009; Froehlich, Findlater, and Landay 2010; Lupton 2014). Moreover, given the difficulty of defining adequate goals externally, and the risk of goal rejection and adverse reactions associated with external goals, these findings question whether IS artifacts should assign goals to users. Our results rather suggest that IS artifacts should encourage users to self-set goals and provide functionalities to store and display them during the target activity.

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