The Role of Psychological Needs in the Relationship between Feedback and Behavior-Opportunities for Sustainable Human-Computer Interaction

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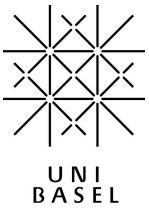
Bachelor Thesis

Institute of Psychology

University of Basel

November 2013



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Abstract

Due to the fact that we are facing serious environmental problems today, enhancing pro-environmental behavior is an interesting target of research. In sustainable Human-Computer Interaction (HCI) research, feedback has often been used to motivate behavior change and was found to be an effective strategy. However, not always after providing feedback actual behavior change was observed. In this work, the self-determination theory of human motivation and the concept of psychological needs, such as competence, autonomy, and relatedness will be discussed in order to reveal the relationship between feedback and behavior modification. It is proposed that when giving feedback it is crucial to account for the psychological needs. As a result, the behaviors are more self-determined or internalized into own values and will therefore lead to long-lasting behavior modification. As a consequence, it is proposed that psychological needs and the resulting motivation act as a mediating variable. Therefore, when feedback satisfies these needs, it can lead to maintained behavior modification, whereas if feedback lacks to satisfy these needs, behavior modification will most likely not take place. Opportunities for empirical research and Sustainable Human-Computer Interaction are discussed.

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Introduction

In terms of environmental issues, the world faces some serious problems. In 2012 the European Commission published the energy efficiency status report. This report states that in 2010 the residential energy sector accounted for 26.65% of total energy consumption. After transportation, it is therefore the sector with the largest energy consumption rate and plays an important role in energy efficiency programmes. Figure 1 shows the sectors and corresponding percentage of total energy consumption. Overall, in the last 20 years the total energy consumption grew almost 7%, and residential energy consumption grew even 12.4%. On one hand, steps towards decreased consumption can be observed, for example a decrease of over 5% between 2005 and 2010. On the other hand, between 2009 and 2010, the residential consumption again increased by more than 4%. Considering these contradictory findings, the report states that when trying to explain consumption patterns it is important to analyse the factors that influence residential energy consumption. It is emphasized that as the increase in the year 2010 shows, it is important that still existing potentials for energy

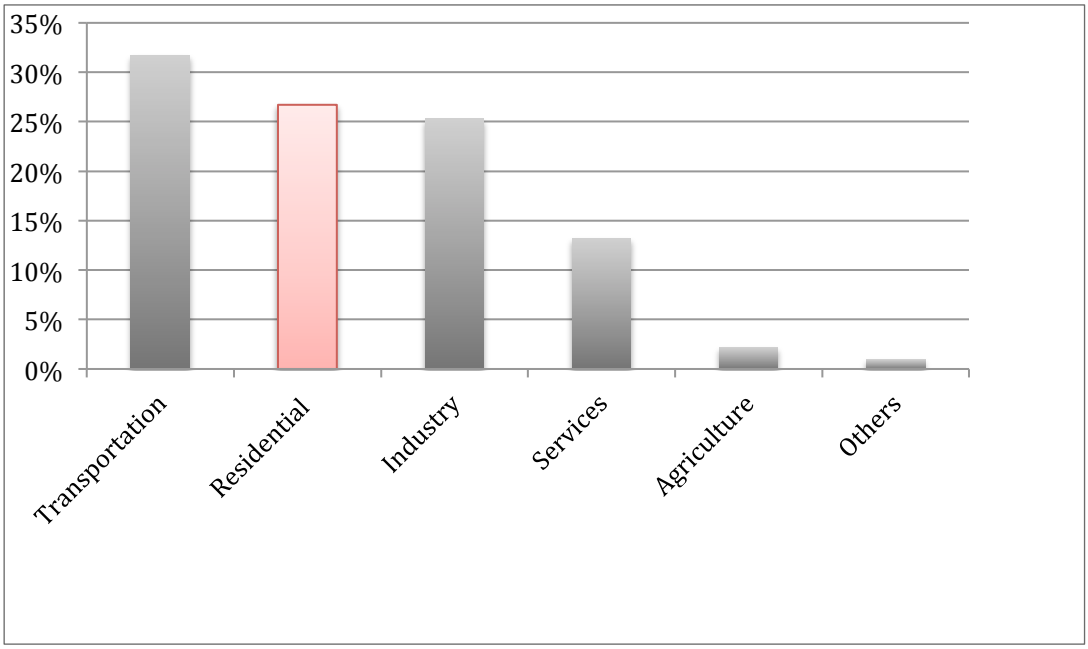

Figure 1. Energy consumption breakdown into sectors in the EU in the year 2010. Adapted from " Energy efficiency status report 2012," by the European Commission, Joint Research Centre, Institute for Energy and Transport, 2012.

efficiency improvements are exploited (European Commission, Joint Research Centre, Institute for Energy and Transport, 2012).

In addition to increasing efficiency through technological means, energy efficiency programs try to influence user's consumption behavior (Petkov, Köbler, Foth, & Krcmar, 2011). Promoting pro-environmental behavior is therefore an interesting target of research because it could reduce residential energy consumption. To attain this, reasons for the observed consumption behavior must be taken into consideration in order to conduct effective interventions.

Generally, the interest in changing human behavior has long been present and thus a large number of information technology systems, known as persuasive technologies, have been developped to change human attitude, behavior or both. (Fogg, 2003). These technologies aim to generate desirable behavior, such as promoting physical activity (IJsselsteijn, de Kort, Midden, Eggen, & van den Hoven, 2006) or pro-environmental behavior (Froehlich, Finlater, & Landay, 2010). Fogg (2003) found that people who were given positive feedback showed positive reactions (e.g. felt better about themselves, felt more powerful etc.). He stated that these positive reactions could lead users to be more open to persuasion and thus promote a designer’s persuasion goals.

Sustainable Human-Computer Interaction (HCI) is research at the intersection of people, technology and environmental concerns and has become a topic in the field of Human-Computer Interaction. This research tries to apply these persuasive technologies that aim to motivate people to behave in a more sustainable way (Petkov et al., 2011). Eco-Feedback is an extension of persuasive technologies that provides feedback on behaviors with the goal of reducing environmental impact (Froehlich et al., 2010). Fischer (2008) found that feedback stimulated energy savings and mentions an

important precondition, namely motivation. It was suggested that feedback affects human motivation and thus enhanced energy-saving behavior. However, this assumption lacks empirical evidence. Many works aimed to motivate pro-environmental behavior and found actual behavior change after providing feedback (Fischer, 2008). Yet, it is not clear why in some studies feedback was an effective strategy in order to enhance pro-environmental behaviors and in some studies no behavior modification was found.

The self-determination theory of human motivation (SDT) will be used to identify the underlying psychological mechanisms that feedback can have on human motivation and behavior. In addition, two subtheories, the cognitive evaluation theory (CET) and the organismic integration theory (OIT) will be helping to get a closer look at human motivation. SDT basically distinguishes between extrinsic and intrinsic motivation**.** Extrinsic motivation refers to doing an activity because it leads to a separable outcome, whereas intrinsic motivation refers to doing something because it is inherently interesting or enjoyable (Ryan & Deci, 2000b). From the SDT point of view, satisfaction of the psychological needs - autonomy, competence, and relatedness - is the basis for self-determined behaviors (Deci & Ryan, 2000). Thus, it is suggested that self-determined behaviors are important when talking about modification and especially maintenance of energy-saving behaviors.

In this work, previous findings from applied Human-Computer Interaction research about feedback and behavior will be presented. In a second step, the underlying psychological processes that might explain these findings will be discussed using the motivational framework SDT. Particular attention will be paid to the role of the psychological needs of competence, autonomy, and relatedness. At the end, need satisfaction will be discussed when examining the effectiveness of feedback on pro-

environmental behavior modification. Opportunities for empirical research and future work are proposed. In sum, a deeper understanding of human motivation and behavior is an opportunity for several domains where behavior change is desired or even necessary.

Feedback, Motivation and Behavior

Feedback to promote pro-environmental behavior

In order to promote pro-environmental behavior, Froehlich et al. (2010) discussed several motivation techniques. One of them is goal setting, which operates through a comparison of the present and the desired future situation. A second one is comparison, either between groups or between individuals. The most widely used means to motivate pro-environmental behavior change is information. The assumption is that with better information, people will act in more environmentally beneficial ways. However, simply presenting information on the benefits typically results in only a marginal effect (Froehlich et al., 2010). Another motivation technique is feedback. It is defined as information that provides a basic mechanism with which to monitor and compare behavior, and allows the individual to better evaluate its performance (Petkov et al., 2011). Many of the motivation techniques discussed by Froehlich et al. (2010) require some sort of feedback. For example goal setting needs feedback about the performance towards a goal. For this reason, feedback is considered to be an important motivation technique and the aim is to understand its impact. One of the best-established findings is the positive effect that feedback can have on performance (Becker, 1978). Fischer (2008) reviewed several studies and found that feedback resulted in energy savings of 5% to 15%. However, in a few instances, no savings were found. It was proposed that preconditions for feedback to work need to be considered carefully and motivation was identified to be a relevant precondition. Based on a model proposed by

Matthies (2005), Fischer described that motivation can activate "other" motives conducive to conservation. In other words, depending on how feedback frames the problem, it can either activate a desire for cost savings or for minimizing environmental impact. Furthermore it is suggested that feedback can stimulate a sense of competition. In order to improve the incentive character even more, feedback could be combined with other instruments, like price incentives, goal setting or a contest (Fischer, 2008).

He, Greenberg, and Huang (2010) pointed out the problem that most technologies provide the same feedback for different individuals. This "one-size-fits-all" solution is therefore difficult, as it provides the same feedback to differently motivated individuals that have different experiences in energy savings. Another approach suggested by Kirman, Linehan, Lawson, Foster, and Doughty (2010) proposed that persuasive technologies may benefit from aversive, in addition to appetitive feedback. Based on Skinner's operant conditioning, they used aversive feedback as some kind of negative reinforcement. The device they designed punished the users when they kept on falling back into undesired behaviors. In a follow-up study conducted by Foster, Linehan, Lawson, and Kirman (2011), posting popular UK chart music on the Facebook wall was used as aversive stimuli. They counted the number of times the participants responded to the posts and the amount of likes. From this, the authors concluded that this aversive type of feedback did not lead to user's disengagement, even though from previous works and authors, it was predicted that decreased engagement will be observed.

In sum, although all of these studies aimed to affect motivation in order to promote pro-environmental behavior in fact found behavior change after providing feedback, it is not clear whether they succeeded in motivating long-lasting behavior changes. The maintenance of behavior is obviously important when talking about

energy consumption patterns and environmental issues. Furthermore, people's motivation or reasons for their more sustainable behavior were not assessed. If an intervention had an influence on behavior, the effect was simply ascribed to increased motivation. However, this assumption was not tested systematically. Also Petkov et al. (2011) highlight this problem: They state that monitors that deliver energy-usage feedback fail to address consumers with different motivations and needs to save energy. They elaborated the potential of socializing energy-related feedback. In other words, by designing a mobile application, they provided feedback based on social comparison (e.g. comparison to neighbours). But also in this study, the mechanisms behind this comparative feedback were not assessed.

In order to understand the relationship between feedback and performance, it is therefore important to understand human motivation in terms of behavior modification. Psychological mechanisms that influence the effectiveness of feedback must be taken into consideration. In the subsequent section, studies that aimed to establish a relationship between feedback and intrinsic motivation will be discussed.

Effect of feedback on intrinsic motivation

Intrinsic motivation has emerged as an important phenomenon in different domains, e.g. education (Ryan & Stiller, 1991) since it showed to be a pervasive and important form of motivation (Ryan & Deci, 2000b). An early study conducted by Harackiewicz (1979) provided evidence that positive feedback on performance enhanced intrinsic motivation, whereas negative feedback diminished it. Another study found that when subjects were threatened by a buzzer while solving a puzzle, they showed less intrinsic motivation for the task (Deci & Cascio, 1972). In contrast to the earlier mentioned study conducted by Foster et al. (2011), Deci and Cascio (1972*)* found that when giving negative feedback or threats of punishment, it led to a decreased

motivation. The explanation was that the external reinforcement (aversive buzzer) provides justification for the behavior and therefore no motivation is triggered. According to the authors, the behavior is ascribed to an external incentive rather than to an intrinsic motivation. To summarize, only positive but not negative feedback was found to enhance intrinsic motivation.

In the study conducted by Deci and Cascio (1972), intrinsic motivation was measured through the amount of time people spent with the original task when they had "free-choice"- time. Harackiewicz (1979) measured intrinsic motivation in a different way. There were five outcome measures of intrinsic motivation made after the experimental manipulation: Enjoyment after the task, time spent during "free-choice"-time, score on a volunteering questionnaire, numbers of extra puzzles (original task) requested, and a posttest of enjoyment one month after the study. She therefore took the aspect of time into consideration, which might be important when talking about behavorial change in terms of environmental issues. Even though intrinsic motivation is considered to be a powerful form of motivation, it could be difficult to always be achieved. Therefore, it is important to understand what kinds of motivation exist and how they can be facilitated and increased.

In order to understand different forms of human motivation and their potential and influence on behavior, the next section aims to take a closer look at the self-determination theory, proposed by Edward Deci and Richard Ryan.

Self-determination theory (SDT)

The self-determination theory is an approach to human motivation and personality and investigates people’s inherent growth tendencies and innate psychological needs. Thus, it highlights the importance of human’s inner resources for personality development and behavorial self-regulations (Ryan & Deci, 2000a). SDT is

chosen for this work because it considers needs to be innate rather than learned and therefore gives motivation content to life.

SDT distinguishes between different types of motivation orientation based on the different reasons or goals that give rise to action. Extrinsic motivation exists whenever an activity is done in order to attain a separable outcome but can vary in its degree of personally endorsed values of the behavior regulations. Intrinsic motivation describes the motivation to do an activity for its inherent pleasure. Because of this inherent nature, intrinsic motivation has shown to be an important form of motivation (Ryan & Deci, 2000b).

Three psychological needs - competence, autonomy, and relatedness - are considered essential for understanding the content and the process of goal pursuits. SDT states that people tend to pursue goals that allow their need satisfaction and as a consequence- personal growth and integrity (Deci & Ryan, 2000). These psychological needs are therefore the basis for people's self-motivation and personality integration. Furthermore, people will become more or less interested in activities as a function of the degree to which they experience need satisfaction while engaging in those activities. Thus, experiences of competence and autonomy are essential for intrinsic motivation (Ryan & Deci, 2000a).

Cognitive evaluation theory (CET)

The cognitive evaluation theory (CET) is a subtheory of SDT and aims to specify factors in the social context that explain variability in intrinsic motivation. (Ryan & Deci, 2000b). CET is framed in terms of factors that either facilitate or undermine intrinsic motivation (Ryan & Deci, 2000a). It argues that interpersonal events and structures (e.g. rewards, feedback) that conduce toward feelings of competence or self-efficacy during action can enhance intrinsic motivation because they allow satisfaction

of the psychological need of competence. CET further specifies that feelings of competence will not enhance intrinsic motivation unless it is accompanied by a sense of autonomy or in attributional terms, an internal perceived locus of causuality (Ryan & Deci, 2000b). Stated differently, in order to maintain intrinsically motivated behaviors, people must experience satisfaction of the needs both for competence and autonomy. (Deci & Ryan, 2000). People must therefore also experience their behavior to be self-determined if intrinsic motivation is to be maintained or enhanced. (Ryan & Deci, 2000b). In other words, perceived competence is necessary for any type of motivation, whereas perceived autonomy is required for the motivation to be intrinsic (Deci & Ryan, 2000).

Organismic integration theory (OIT)

Another subtheory, the organismic integration theory (OIT) scrutinizes the different forms of extrinsic motivation. It was assumed that most activities are not motivated intrinsically as they become increasingly curtailed by social demands, especially after childhood. In learning environment, it was acknowledged that more active and volitional forms of extrinsic motivation become an essential strategy for successful teaching (Ryan & Deci, 2000b). OIT therefore details different forms of extrinsic motivation and the contextual factors that either promote or hinder internalization of the regulations of these behaviors. (Ryan & Deci, 2000a).

Internalization is understood as active and natural process in which individuals attempt to transform socially sanctioned requests into personally endorsed values. Individuals thus assimilate these regulations into their integrated sense of self and fully accept them as their own. As a result, different types of extrinsic motivation vary in the extent to which they are controlled versus autonomous (Deci & Ryan, 2000). Figure 2 shows the continuum of types of motivation with their regulatory style and loci of

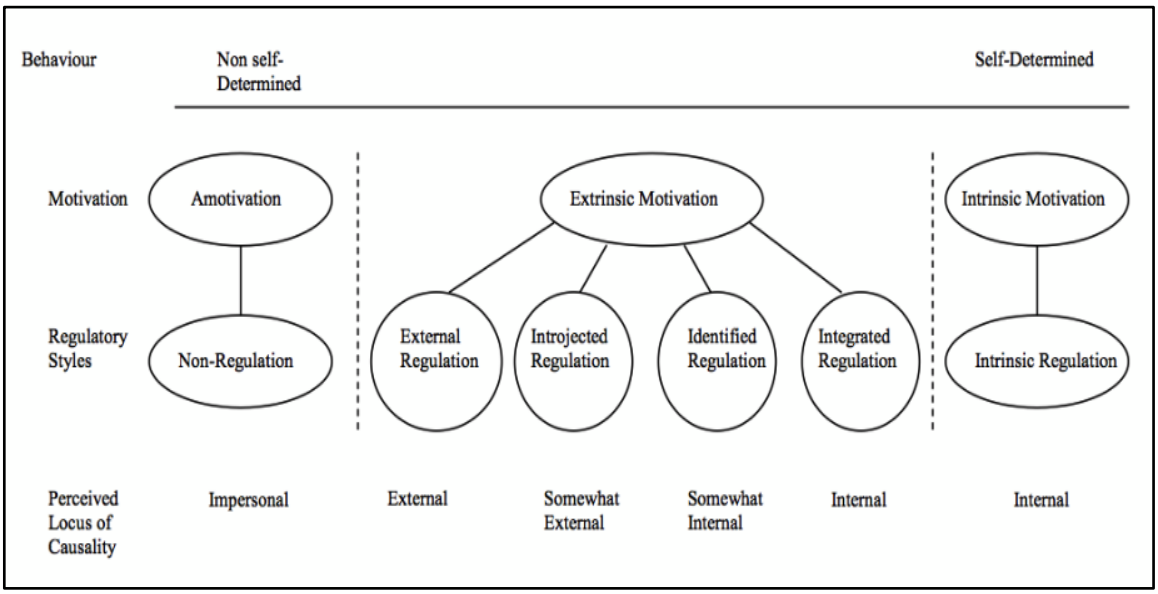

Figure 2. Continuum of types of motivation with their regulatory style and loci of causuality. Adapted from "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being," by R.M. Ryan, and E.L. Deci, 2000a, *American Psychologist, 55*(1), pp. 68-78.

causuality.

On the leftmost end of the continuum, amotivation is the state in which people lack the intention to behave and thus lack motivation. According to SDT, people are likely to be amotivated when they lack either a sense of efficacy or a sense of control with respect to a desired outcome. External regulation is a process in which people's behavior is controlled by external contingencies (Deci & Ryan, 2000). This is the only type of regulation recognized in operant theory (Skinner, 1938). The behaviors are predicted to show poor maintenance and transfer once contingencies are withdrawn. Introjection represents a partial internalization in which regulations are in the person but have not really become part of the integrated set of motivations, cognitions and affects that constitute the self. Thus, the behaviors are not self-determined and they remain a relatively unstable form of regulation. Identification is the process through which people recognize and accept the underlying value of a behavior. By identifying with a

behavior's value, people have more fully internalized its regulation. These regulations based on identification are expected to be better maintained. Integration is the most complete part of internalization of extrinsic motivation because it also integrates those identifications with other aspects of the self. They are brought in coherence with other aspects of their values and identity. The result is self-determined extrinsic motivation. Intrinsic motivation on the rightmost of the continuum is the prototype of self-determined behavior (Deci & Ryan, 2000).

SDT states that some behaviors could for example begin as introjects because of an external regulation such as a reward. Then, if this reward is not too controlling, such exposure might allow the person to experience the activity's intrinsically interesting properties, resulting in an orientation shift (Deci & Ryan, 2000). Furthermore, internalization and emotional integration are shown to be facilitated by conditions that fulfil psychological needs for autonomy, competence, and relatedness. Interactions between psychological needs and contextual support account for the integration and specifity of motivation (Ryan, 1995). To summarize, intrinsic motivation and well-internalized extrinsic motivation are the basis for autonomous or self-determined behavior.

Discussion

Feedback, Motivation and Behavior

In order to attain pro-environmental behavior change, several studies provided feedback. In most cases, this turned out to be an effective strategy (Fischer, 2008). However, it is a striking fact that in some studies, no impact was observed. This brings up the question to the reasons and circumstances in which feedback is in fact an effective way to change behavior. Feedback is considered to motivate people and if

actual energy savings were found, it was attributed to have increased motivation. However, seldom it was checked if people were actually motivated and if so, which kind of motivation was present. Satisfaction of the psychological needs of competence, autonomy, and relatedness are considered to be the basis for intrinsic motivation and self-determined behavior. From the SDT point of view, people will become more or less interested in activities as a function of the degree to which they experience need satisfaction while enganging in those activites (Ryan & Deci, 2000a). Therefore, it might be a possible explanation that this need satisfaction is a factor that influences the outcome, namely behavior. In the mentioned studies it is not clear whether these needs were satisfied, since it was not a research question and as a consequence it was not assessed. These studies from applied HCI research generally aimed to take motivational factors into consideration. As an example, Foster et al. (2011) explicitly mentioned Skinner's operant theory. Based on negative reinforcement, they provided aversive feedback when the users showed undesired behavior in order to make this behavior less likely to occur. Also He et al. (2010) aimed to develop a motivational framework by considering psychological literature. As a result, they then gave examples of how to apply their recommendations. They stated that when providing feedback about energy usage, the same feedback to differently motivated individuals and thus a "one-size-fits-all" solution is not ideal. However, they did not specify what exactly motivated users and were not looking for any specific patterns. One could argue that when looking for patterns, some people's psychological needs are satisfied through the kind of feedback they received and some people's needs were not satisfied.

Generally, if people feel competent, autonomous and experience relatedness, the interaction with a device is probably more pleasant compared to a device that through its feedback makes them feel stupid and incompetent. Furthermore, the positive

experience when need satisfaction is given might be associated with the device. One might question why researchers (Deci& Cascio, 1972; Foster et al., 2011) found different results concerning aversive or negative feedback. Deci and Cascio (1972) found that negative feedback decreased intrinsic motivation. The authors stated that negative feedback leads to a decreased motivation because of the external constraint that is present. Furthermore, the negative feedback as such might be associated to a negative experience because people felt threatened in their need for autonomy and thus psychological need satisfaction might be difficult to be achieved. Foster et al. (2011) stated that users were not disengaged when aversive feedback was provided. However, it is highly questionable if only measuring the amount of responses to aversive posts, comments and likes are reliable measurement methods of motivation.

Having these considerations in mind, depending on how feedback meets the psychological needs, the resulting energy-usage behavior is different. Thus need satisfaction and the resulting motivation could mediate the relationship between feedback and behavior.

Need satisfaction as Mediating Variable

Baron and Kenny (1986) described a mediator as a variable that explains the relation between a predictor and an outcome variable. A variable functions as a mediator to the extent that it accounts for the relation between the predictor and the criterion. Mediating variables are typically introduced when there is already a strong relation between a predictor and an outcome and one wishes to explore the mechanisms. (Frazier, Tix, & Barron, 2004). Similarly, feedback was found to influence behavior, but reasons for the effectiveness are not completely clarified.

In this work, it is therefore proposed that need satisfaction and the resulting motivation might be the mediating variable that accounts for the effectiveness of feedback on pro-environmental behavior modification. Figure 3 shows a model of mediation (Ketchen, Boyd, & Bergh, 2008) by assuming a three-variable system with two causual paths (the predictor variable and the mediator) feeding into the outcome variable (Frazier et al., 2004).

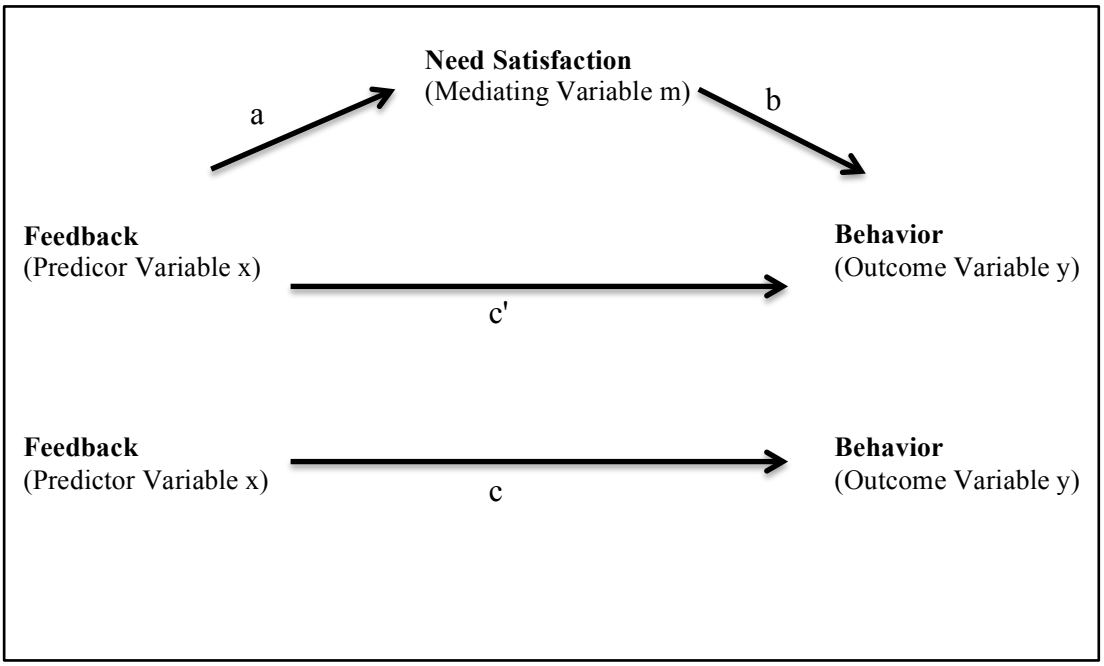

Figure 3: Model of Mediation Including the Variables Feedback, Need Satisfaction and Behavior. Adapted from " Research methodology in strategic management past accomplishments and future challenges," by D.J. Ketchen, B.K. Boyd and D.D. Bergh, 2008, *Organizational Research Methods*, *11*(4), pp. 643-658.

The first step in a mediator analysis is to show that there is a relation between predictor and outcome, so between feedback and behavior, which could be shown by Fischer (2008). The second step is to show that the predictor is related to the mediator. Deci and Cascio (1972) were able to provide evidence for this relation. The third step is to show that the mediator is related to the outcome variable, that motivation is related to performance. Here, SDT states that behaviors based on integration are expected to be

better maintained. Finally, the relation between feedback and behavior (predictor and outcome variable) should be significantly smaller when it is not accounted for psychological needs that enable motivation. However, it is highly likely that there are multiple mediating variables because in most areas of psychology, phenomena have multiple causes (Baron & Kenny, 1986). Generally, involving multiple mediators has received little attention, but in behavorial sciences, there is a clear need for it (Preacher & Hayes, 2008). As an example, a mental disorder (outcome variable) is usually not the result of only one predictor (e.g. trauma in childhood), but this outcome is mediated by several other variables (e.g. coping strategies, social support, personality traits etc.).

Having this mediation model in mind (see Figure 3) it is an interesting fact that in a study conducted by Ueno, Sano, Saeki, and Tsuji (2006), feedback led to a 9% reduction in power consumption when an energy- consumption information system was installed. Daily-load curves and load-duration for each appliance revealed several energy-saving behaviors (e.g. the reduction of standby power) and allowed better control of appliance operation. As a consequence, people were able to save energy because they knew about the consequences of their behavior. They therefore experienced competence and self-efficacy in terms of energy savings. In contrast, in a study conducted by Bittle,Valesano, and Thaler (1979), families whose consumption rate was previously low even increased their consumption after having received feedback. One could argue that people already low in consumption do not feel competent to save more energy due to their already low starting point. Since their consumption rate was already low and they did not feel able to decrease their consumption any more, the need of competence could not be satisfied. In these studies people might only experienced competence when their actions resulted in the desired outcome, which is a lower consumption rate. This is also interesting when comparing

these ideas to a study by Vallerand and Reid (1984), where it was already shown that enhancing motivation through feedback was mediated by perceived competence. In other words, people only showed increased intrinsic motivation when they felt competent.

According to this proposed mediation model, it is also important that people feel connected to others and experience relatedness. People might feel like they belong to a group if the feedback they received is positive, especially compared to others. As a consequence, they feel integrated and accepted because of their good results and consumption rate. Considering again the study conducted by Bittle et al. (1979), people might also have felt excluded from the group. Because of their already low consumption rate, they might have realised it was not possible for them to achieve a good conservation rate compared to the other participants. In terms of relatedness, Petkov et al. (2011) were looking for possible motivations and discussed the factor "appraisal from others". However, in preliminary interviews none of participants mentioned this social validation as their primary motivation. A possible explanation is that, similar to competence, the need for relatedness is not the primary goal, but a required precondition for the interaction and the impact of feedback to be effective.

It is also proposed that making sure that people feel autonomous in their behavior is important. The importance of autonomy for increased motivation could be shown by Ryan (1982): Controlling feedback- thus a decreased autonomy- undermined intrinsic motivation. When considering applied HCI studies, one might question to what extent people initially felt autonomous to conduct a behavior. When participating in a study that is about energy conservation, to a certain extent people probably feel forced to "perform better" because it is the aim of the study. This means that initially, they probably do not feel that their behavior is completely autonomous and thus it is not

intrinsically motivated. From the SDT point of view, perceived competence is important for any kind of motivation, whereas autonomy is required for the motivation to be intrinsic (Deci & Ryan, 2000). One could argue that people are initially motivated because they experience competence, but only a low level of autonomy. Thus, at the beginning the motivation is probably extrinsic and not self-determined because of the low level of autonomy. When talking about intrinsic motivation to conduct a behavior, it is typically understood as doing a task because it inherently enjoyable. It is highly questionable if trying to save energy and focusing on pro-environmental behavior is inherently enjoyable and done for its mere pleasure. Compared to pursuing one's passion (for some people e.g. dancing, play at theatre, play computer games etc.) which is intrinsically motivated, switching the TV off when it is not used anymore is probably not done because it is inherently enjoyable. Having said this, people might participate in these studies because they are generally interested in environmental issues and like technical appliances, so they are motivated with a certain degree of autonomy. They might enjoy interaction with these devices, but the actual goal, improving energy saving behavior initially may be seen as some kind of welcome side effect. Consequently, if energy-saving behaviors are not perceived completely self-determined and intrinsically motivated, it is important to focus on more externally motivated behaviors and how they can be integrated. If this internalization succeeds, behaviors are not done anymore only for external reasons but have become internalized.

Internalization is shown to be facilitated by conditions that fulfil psychological needs (Ryan, 1995). Obviously if the aim is to achieve long-lasting behavior modification, people must conduct behaviors because of its significance for the individual's value system, otherwise they are not maintained over time. When trying to address motivation at first stage, external motivators such as monetary incentives are

often proposed. Initially, this probably triggers some kind of positive reinforcement to motivate desirable behavior. However, people's reason for the conducted behavior are then justified with this external incentive, rather then attributed to internal values that triggered this behavior. Most behaviors are initially driven by extrinsic reasons, but in this case the aim is that these behaviors result in an orientation shift to more integrated behavior, so that e.g. former "introjected" behaviors become "integrated" behaviors. If this is the case, long-lasting behavior modifications can be attained (Deci & Ryan, 2000). If people interact with devices, initially for reasons associated with enjoyment and they then continue this interaction, one day they will need an explanation for their ongoing interaction and their energy-saving behavior. It is a well-established finding that people make inferences from their behavior on their attitude and on their personality traits (Ajzen, 1997). This was also found by Bem (1973): He proposed the self-perception theory, in which the claimed that people infer their attitudes by observing their own behavior. Furthermore, it is important for an individual to be consistent in its self-concept and act consistently (Smith & Mackie, 2007). Attitudes are constructed on the basis of cognitive, affective, and behavorial information, so it makes sense that attitudes are consistent with actions. Therefore, collecting cans for recycling can help to develop caring attitudes towards environmental conservation. Furthermore, people make inferences from behavior especially when attitudes are weak or ambiguous (Smith & Mackie, 2007). This seems to be an important mechanism because for most people, environmental attitudes are probably ambigous. On one hand, they want to contribute to decreasing environmental impact, on the other hand, they do not want this contribution to become the centre of their lifes.

So if people initially just enjoy interaction with a device but go on using it and as a result are able to save energy, over time they might integrate their behavior and

conclude that they are still using the device and saving energy because they care about environmental issues. Then, sustainable behaviors are seen as part of the individual's value system and are more likely to be maintained. From the SDT point of view, some behaviors could begin as introjects (Deci & Ryan, 2000). However, if a person originally gets exposed to an activity because of an external regulation (e.g. a reward), such exposure might allow the person to experience the activity's intrinsically interesting properties, resulting in an orientation shift. This shift is likely when these values have also been integrated with other aspects of the self. (Ryan, 1995). In order to stay consistent (Smith & Mackie, 2007), this behavior is then shown more frequently and a stable behavior can be established. As a consequence, previously externally motivated behavior can become integrated and if this succeeds, the result is self-determined and thus long-lasting behavior.

Considering these thoughts, it is a challenge to conduct empirical studies and measure motivation, behavior, and attitudes. If initially externally motivated behaviors become internalized only over time, it is difficult to attain a internalization of behavior within a regular time of a study that usually does not take longer than one hour. Harackiewicz (1979) considered this aspect by conducting a posttest of enjoyment one month after the study. This seems valuable because the behavior is probably still extrinsically motivated but because of internalization of values, with a high level of autonomy. If behaviors are integrated, they are stable over time and behavior should be measured an additional time. In terms of energy consumption, motivation and behavior could be measured with the help of social media as proposed by Petkov et al. (2011). Social media devices seem to have great potential because they are able to track behaviors and automatically provide feedback. Following the ideas from Harackiewicz (1979) and Petkov et al. (2011) several steps might be taken: First, self-reported

enjoyment and motivation immediately after the manipulation could be measured. In a second step, free-choice time might be provided in order to investigate what amount of time people still spend with the device, thus how intrinsically interesting it is for them. Behavior can then be tracked over time and the amount of interaction with the device can be measured, which gives information about the stability of the behavior. As proposed by Harackiewicz (1979), a posttest one month after the manipulation might be conducted to investigate if motivation and the resulting behaviors are long-lasting. It is proposed that this posttest should not only integrate enjoyment, but also attitudes towards environmental issues. By doing this, the degree to which caring attitudes towards the environment have been internalized and thus the degree of self-determined behavior can be concluded.

To summarize, if psychological needs are satisfied, people will probably go on interacting with the device and enjoy this interaction. One hand, they then interfere from their behavior to their attitude and adopt these behaviors because they have become part of the value system. On the other hand, with increasing time spent interacting with the device, it is more likely that people discover intrinsically interesting motives. As a result, an orientation shift into more internalized behaviors can be attained.

Future work and limitations

Based on the theoretical implications of this work, opportunities for future research are to test the hypothesis that psychological needs act as a mediator in the relation of feedback and behavior experimentally. The degree of need satisfaction might be used as independent variable and behavior as dependent variable. Before being able to measure behavior over time, the most important question is how to systematically induce and vary need satisfaction. Different kinds of feedback might be provided and to

check if this "need induction" works, the resulting motivation needs to be measured. After having made sure that need induction worked, its degree of satisfaction can now be varied systematically. As the dependent measure, behavior can then be observed and "low" and "high" need satisfaction conditions can be compared. If then the "high need satisfaction" condition results in long-lasting behavior modification, the importance of these needs can be shown.

Finding additional mediators in the feedback- behavior relationship is another question that should be investigated in future research. In order to understand what factors determine behavior and maintenance of behaviors, there are probably more mediators than need satisfaction that have an influence. Possible additional mediators are the situational factors. To mention just one example, when people are in time pressure and lack cognitive resources, internalization will probably be more difficult. People will process their own behavior more superficially and inferences from behavior on attitudes will most likely not take place (Svenson & Maule, 1993).

An interesting limitation is the question if people, depending on their cultural background, have the same extent of desired need satisfaction. Hofstede (2001) focused on intercultural communication and he stated that culture plays a significant role in forming the ways of feeling, thinking and acting. Because of the fact that in collectivistic societies the group is more important than the individual, it might be possible that these people have a lower need for individual growth and thus need satisfaction might play a minor role.

Maréchal (2009) used a different approach to behavior modification: He points out the importance of habits- not fully conscious forms of behavior- and policies aiming to reduce energy consumption addressing the performance context. However, he acknowledges that the use of feedback is promising. Further studies should therefore

also take the aspect of habits into consideration, as they might be an interesting research target if combined with psychological need satisfaction. If behaviors are "locked in", they have already become habits and will most likely be conducted again. In terms of environmental issues, "bad" habits are a problem and the aim is to "unlock" them. Through the use of feedback and when accounting for psychological needs, unlocking these bad habits might be achieved or facilitated.

Knowledge of the effect of feedback on motivation and behavior can also be transferred to several additional domains. Enhancing individual health behavior and preventing undesired consequences (e.g. prevent undesired health costs, extend individuals life expectancy through healthier lifestyle etc.) is only one example that illustrates that improving the effect of feedback on behavior could be of great value.

Conclusion

This work aimed to investigate the relationship between feedback, motivation and behavior while trying to find opportunities to enhance pro-environmental behavior. It is proposed that it is crucial to understand the underlying psychological processes that determine the effectiveness of feedback on behavior. When accounting for the psychological needs of competence, autonomy, and relatedness, the effectiveness of feedback in terms of behavior modification might be improved. Through need satisfaction, intrinsic motivation or well-internalized extrinsic motivation can be enhanced and as a consequence influence behavior. Intrinsic motivation is not the only opportunity to motivate behavior. On the opposite, it seems promising to focus on integrating externally motivated behaviors, as they might become internalized over time.

In future, empirical studies should aim to test the hypothesis of psychological need satisfaction as mediating variable experimentally. Sustainable Human-Computer Interaction may benefit from these findings: If designing applications, it is an

opportunity to check if feedback satisfies psychological needs in order to make the feedback- giving device more efficient. In sum, when successfully designing devices with the goal of enhancing pro-environmental behavior, this work might contribute to the reduction of environmental impact due to human behavior.

References

Ajzen, I., & Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin, 84*(5), 888-918.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Becker, L. J. (1978). Joint effect of feedback and goal setting on performance: A field study of residential energy conservation. *Journal of Applied Psychology, 63*(4), 428-433.

Bem, D. J. (1973). *Self-perception theory.* London, England: Academic Press Inc..

Bittle, R. G., Valesano, R. M., & Thaler, G. M. (1979). The effects of daily feedback on residential electricity usage as a function of usage level and type of feedback information. *Journal of Environmental Systems, 9*(3), 275-287.

Deci, E. L., & Cascio, W. F. (1972, October). *Changes in intrinsic motivation as a function of negative feedback and threats.* Paper session presented at the meeting of the Eastern Psychological Association, Boston.

Deci, E. L., & Ryan, R. M. (2000). The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

European Commission, Joint Research Centre, Institute for Energy and Transport. (2012). *Energy efficiency status report 2012,* (JRC Publication No. 69638). Retrieved from http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/energy-efficiency-status-report-2012.pdf

Fischer, C. (2008). Feedback on household electricity consumption: A tool for saving energy?. *Energy Efficiency*, *1*(1), 79-104.

Fogg, B. J. (2003). *Persuasive technology: Using computers to change what we think and do*. San Francisco: Morgan Kaufmann.

Foster, D., Linehan, C., Lawson, S., & Kirman, B. (2011). Power ballads: Deploying aversive energy feedback in social media. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems* (pp. 2221-2226).

Frazier, P. A., Tix, A. P., & Barron, K. E. (2004). Testing moderator and mediator effects in counseling psychology research. *Journal of Counseling Psychology, 51*(1), 115-134.

Froehlich, J., Findlater, L., & Landay, J. (2010). The design of eco-feedback technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1999-2008).

Harackiewicz, J. M. (1979). The effects of reward contingency and performance feedback on intrinsic motivation. *Journal of Personality and Social Psychology, 37*(8), 1352-1363.

He, H. A., Greenberg, S., & Huang, E. M. (2010). One size does not fit all: Applying the transtheoretical model to energy feedback technology design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 927-936).

Hofstede, G. H. (Eds.). (2001). *Culture's consequences: Comparing values, behaviors, institutions and organizations across nations*. Thousand Oaks, CA: Sage Publications, Inc..

IJsselsteijn, W., de Kort, Y., Midden, C., Eggen, B., & van den Hoven, E. (Eds.). (2006). *Persuasive technology for human well-being: Setting the scene*. Berlin-Heidelberg: Springer-Verlag GmbH, 1-5.

Ketchen, D. J., Boyd, B. K., & Bergh, D. D. (2008). Research methodology in strategic management past accomplishments and future challenges. *Organizational Research Methods*, *11*(4), 643-658.

Kirman, B., Linehan, C., Lawson, S., Foster, D., & Doughty, M. (2010). There's a monster in my kitchen: Using aversive feedback to motivate behaviour change. In *CHI'10 Extended Abstracts on Human Factors in Computing Systems* (pp. 2685-2694).

Maréchal, K. (2010). Not irrational but habitual: The importance of "behavioural lock-in" in energy consumption. *Ecological Economics, 69*(5), 1104-1114.

Matthies, E. (2005). Wie können PsychologInnen ihr Wissen besser an die PraktikerIn bringen? Vorschlag eines neuen, integrativen Einflussschemas umweltgerechten

Alltagshandelns. [How can psychologists improve their outreach towards practitioners? A suggestion for a new, integrative model of environmentally sound everyday practice]. *Umweltpsychologie, 9*(1), 62–81.

Petkov, P., Köbler, F., Foth, M., & Krcmar, H. (2011). Motivating domestic energy conservation through comparative, community-based feedback in mobile and social media. In *Proceedings of the 5th International Conference on Communities and Technologies* (pp. 21-30).

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879-891.

Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology*, *43*(3), 450-461.

Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *Journal of Personality, 63*(3), 397-427.

Ryan, R. M., & Deci, E. L. (2000a). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Ryan, R. M., & Deci, E. L. (2000b). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54-67.

Ryan, R. M., & Stiller, J. (1991). The social contexts of internalization: Parent and teacher influences on autonomy, motivation, and learning. In P.R. Pinrich & M.L. Maehr (Eds.), *Advances in motivation and achievement* (pp. 115-149). Greenwich: JAI Press.

Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis.* Oxford, England: Appleton-Century.

Smith, E. R. & Mackie, D. M. (2007). Attitudes and behavior. In E.R. Smith, & D.M. Mackie (3rd ed.), *Social psychology.* Madison Ave, New York: Psychology Press.

Svenson, O., & Maule, A.J. (1993). *Time pressure and stress in human judgment and decision making.* Berlin-Heidelberg: Springer-Verlag GmbH.

Ueno, T., Sano, F., Saeki, O., & Tsuji, K. (2006). Effectiveness of an energy-consumption information system on energy savings in residential houses based on monitored data. *Applied Energy, 83*(2), 166-183.

Vallerand, R. J., & Reid, G. (1984). On the causal effects of perceived competence on intrinsic motivation: A test of cognitive evaluation theory. *Journal of Sport Psychology, 6*(1), 94-102.