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THE ROLE OF GOAL FRAMES REGARDING THE IMPACT OF GAMIFIED PERSUASIVE SYSTEMS ON SUSTAINABLE MOBILITY BEHAVIOR

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Research

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Abstract

This study analyzes the motivational processes of a gamified persuasive system in an initiative to encourage sustainable mobility behavior by promoting bike usage. To increase motivation and drive sustainable behavior, the design of persuasive systems is gradually advancing. Game-based functions are often implemented to transform the user experience through playful interactions. This paper explores whether the functions implemented within gamified persuasive systems really fulfill an individual's goals and needs by analyzing the impact of the user's personal goals on gamified persuasive system usage and the desired outcome in the domain of sustainable mobility behavior. The theoretical basis for this study comes from the goal-framing theory as well as the perspective of functional affordances. The results in this work indicate that the functions implemented are only partially compatible with user goals. Furthermore, the results demonstrate that the influence of goals on sustainable mobility behavior can be increased through the implementation of specific functions within a persuasive system.

Keywords: Persuasive System, Gamification, Goal-Framing Theory, Sustainability, Affordances

1 Introduction

Climate change and our responsibility for its effects on the equilibrium of global ecology has become a central issue in today's society. If no actions are taken, worldwide temperatures are expected to increase by over two degrees by 2035 (IEA 2007) due to a 27% rise in carbon dioxide emissions since 2000 (Filcak et al., 2013). Recent studies indicate that a large part of these emissions are caused by human activities, with the transportation sector responsible for 14% of the total CO_2 emissions (IEA 2007). Despite recent political efforts to reduce these emissions (e.g., tax regulations, road tolls), the number of cars per household is still increasing while the use of other transportation options, including walking and cycling, drops (Filcak et al., 2013). These concerning numbers highlight the possibility of changing future developments by shifting individual mobility habits. Thus, it is clear that people should be motivated to change their mobility behavior in order to reduce greenhouse gas emissions; the question is how this can be achieved. It is therefore the duty of various research disciplines and policymakers to determine a way to galvanize people into engaging in more sustainable mobility behavior (Gifford, 2011; Osbaldiston and Schott, 2011).

In an emerging area of IS research referred to as Green IS, researchers aim to address environmental problems by improving information supply and stimulating behavioral changes through offering better solutions and information as well as employing incentive mechanisms (e.g., Hilpert et al., 2013; Watson et al., 2010). Accordingly, Green IS can be helpful to motivate people to change their personal mobility routines. Currently , various persuasive systems have been applied to achieve a shift towards a more sustainable behavior (e.g., Björkskog et al., 2010; Shiraishi et al., 2009) with the goal to reinforce, change, or shape attitudes or behavior (Fogg, 2002; Oinas-Kukkonen and Harjumaa, 2009). For example, Tulusan et al. (2012) developed a smartphone application with a feedback mechanism to improve fuel efficiency. The 50 corporate car drivers under investigation improved their overall fuel efficiency by 3%, even without direct financial incentives.

The success of such persuasive IS is fostered by the emerging digital society, who grow up with the wide availability of computers, video games, digital music players, and mobile phones (Myers and Sundaram, 2012; Prensky, 2001; Yoo, 2010). Due to their continual interaction with IS, this generation has special needs, wishes, expectations, and behaviors concerning IS and require IS design that supports social life, gratification, feedback, and playful experience (Myers and Sundaram 2012). Hence, the design of persuasive systems is gradually advancing to increase motivation and drive sustainable behavior. Especially, the implementation of additional game-based functions to transform the user experience through playful interactions is often performed in different contexts (Blohm and Leimeister, 2013). However, to the best of our knowledge, no empirical study has explored whether the implemented functions within gamified persuasive systems really fulfill an individual's goals and needs. Consequently, the desired motivational process to encourage sustainable behavior is questionable (Huotari and Hamari, 2012). Prior research has already addressed this issue and pointed out the importance of user perceptions and goals in determining the value of persuasive systems (Huotari and Hamari, 2012).

In this paper we address these research gaps in an explorative attempt by analyzing the impact of users' goals on gamified persuasive system usage and the desired outcome in the domain of sustainable mobility behavior. In this respect, our paper focuses on the following questions: First, to what extent are the functions implemented compatible with the user's goals? And second, what is the relationship among the user's goals, the functions used, and the desired sustainable behavior outcome? The theoretical bases for this study are the goal-framing theory (Lindenberg und Steg, 2007) and the perspective of functional affordances (Markus and Silver, 2008). Functional affordances describe the capabilities of technical artifacts to support an individual's targeted actions (Markus and Silver, 2008), meaning that an information system only serves as a helpful instrument if it satisfies the expected tasks. In Green IS, functional affordances have primarily been studied in organizational contexts using a qualitative approach (Seidel et al., 2013) – not in the context of gamified persuasive systems in the private sector. Therefore, further research about functional affordances in the domain of Green IS is necessary, as affordances are very technology and user specific (Strong et al., 2014). The goal-framing theory is well established and has been applied successfully in psychological research regarding sustainable behavior. The theory is concerned with the alignment of personal goals and a given – generally less appealing – goal due to increased efforts or expenses (Lindenberg and Steg, 2007).

In this study the gamified persuasive system is represented by a website with various functions of a sustainability initiative in Germany that aims to increase bike use and thus reduce CO_2 emissions. In 2014 the initiative had over 86,000 registered participants from more than 280 communes, organized in 6,905 teams during the entire timespan from May 1st to September 30th. The participants cycled an overall distance of more than 16 million kilometers, saving 2,360 tons of CO_2.

The findings of this study are transferable to other implementations of gamified persuasive systems with the goal of motivating sustainable behavior and contributing to a successful design. Our research helps to increase the understanding of the motivational process of gamified persuasive systems and the impact of such systems on individual behavior.

2 Theoretical Background

2.1 Persuasive systems

Persuasive systems are designed and applied to change behavior through the use of information technology. They are intelligent approaches interacting with human behaviors and have the clear aim of influencing these behaviors in a desirable direction (Fogg, 2002). In the domain of sustainable behavior, persuasive systems are often deployed in the energy sector (e.g., Loock et al., 2013; Lui et al., 2013). For example, Fischer (2008) conducted a literature review of 25 publications appearing between 1987 and 2007 that examined the effects of persuasive systems on electricity consumption, consumer reactions, attitudes, and wishes concerning the design of the persuasive system. In the mobility domain, the application of persuasive systems is on the rise (e.g., Flüchter et al., 2014; Tulusan et al., 2012). For example, Froehlich et al. (2009) created a mobile phone–based application that aims to expand personal awareness of mobility behavior. Graphical rewards, depicted by pop-up icons, are earned by using green transportation alternatives, such as buses, trains, bikes, carpooling, or walking. Their results reveal that the artifact increases participants' awareness and stimulates or even strengthens their reflection about transportation activities. However, all studies were conducted with only small sample sizes, putting the significance of the results in question.

To increase the motivation of engagement towards sustainable behavior even further, game functions are used as an extension of persuasive systems to transform people's behavior through playful experiences (Blohm and Leimeister, 2013). This so-called gamification approach (Lounis et al., 2014) aims to satisfy various evolution-dependent goals or needs by integrating an assortment of game-based functions into a persuasive system. Needs are conditions within an individual that are essential and necessary for the maintenance of life and the nurturance of growth and well-being (Zhang, 2008). Table 1 illustrates the relationship between game-based functions and their underlying needs.

Game-based functions	**Needs/Goals**
Documentation of own behavior	Exploration
Point systems, badges	Collection
Ranking list	Competition
Levels, reputation points	Status acquisition
Group tasks	Teamwork
Time pressure, task, mission	Challenge
Avatar, virtual worlds	Development, organization

Table 1. Overview of different types of game-based functions in relation to the needs they meet, in reference to Blohm and Leimeister (2013).

The trend of employing gamified functions in non-game environments has become widespread in various areas, including innovation, marketing, education, sustainability, employee performance, health, and social change (Hamari et al., 2014). Several studies have proven gamified design of persuasive systems to be a successful tool for motivating users in various contexts (e.g., Jones et al., 2014; Kampker et al, 2014; Thiebes et al., 2014). However, most of these studies either investigate the short-term impact on behavior of a specific persuasive artifact with several implemented functions (Hamari et al., 2014; Kankanhalli et al., 2012) or review evaluated functions within existing artifacts (e.g., Lee et al., 2013; Oduor et al., 2014; Simões et al., 2013). Previous studies solely examined fundamental questions about the success, types, design elements, and definitions of gamified persuasive systems with the aid of case studies (Schlagenhaufer et al., 2015). Quantitative studies yield predominantly positive effects of gamified persuasive systems and studied outcomes, whereas qualitative studies indicate that the motivational process behind the gamified persuasive system is more complex than most studies often suggest (Schlagenhaufer et al., 2015). Thus, there is a need for more detailed research on the underlying motivational process of single implemented functions within the persuasive system in a quantitative approach on the basis of fundamental interdisciplinary theories (e.g., Kankanhalli et al., 2012; Torning and Oinas-Kukkonen, 2009).

2.2 The concept of affordances in the context of a gamified persuasive system

Affordances are generated by the features of an artifact as well as the user's attributes and potential (Pozzi et al., 2014). In the IS domain, affordances are summarized as the concurrence of organizational goals and capabilities with the features of an applied IT artifact to fulfill a certain purpose (Pozzi et al., 2014). The theory of motivational affordances is applied in the context of gamified persuasive systems (Hamari et al., 2014; Deterding, 2011; Tan et al., 2015; Weiser et al., 2015) in order to justify their motivational processes. Motivational affordances are perceived when the implemented features of an IS trigger and satisfy the user's needs (Zhang, 2008), just as gamification intends to do (see Table 1). Thus, users are more engaged in their actions and feel enjoyment (Zhang, 2008). However, the outcome of these gamified persuasive systems is questionable (Huotari and Hamari, 2012). It is suggested that the insular usage of gamified applications does not necessarily lead to the desired affordances, because users may experience the same functions differently (Huotari and Hamari, 2012). Weiser et al. (2015) created a taxonomy of motivational affordances for the design of persuasive systems in the domain of sustainable mobility behavior. However, they advise against the non-reflected application of the taxonomy and highlight the strong dependency of affordances on contextual factors, e.g., the users' characteristics and their personal needs and goals.

To explore the impact and motivational process of the functions implemented within a gamified persuasive system on each user, we propose the concept of functional affordance as a more suitable alternative. As suggested by Markus and Silver (2008), this concept is very fitting for analyzing why the effects of IS may differ in various contexts. When affordances enable or constrain actions in a given organism or organization, the affordances of an artifact are described as functional (Hutchby, 2001; Leonardi, 2013). Thus, functional affordances build a bridge between an IS artifact and users, providing the opportunity to describe the variable effects of IS usage for different users (Balci et al., 2014). Past studies about functional affordances, however, focus not on the individual user but rather on the mechanism connecting IS features with networks in organization and thus on collective and shared affordances, i.e., group-level affordances (Balci et al., 2014; Savoli and Barki, 2013). To emphasize the individual user, the concept of *perceived* functional affordances (PFA) was introduced (Savoli and Barki, 2013). The concept of PFA considers functional affordances perceived by each individual in reference to his or her own goal; each user generates a "mental image of its capabilities and constraints (i.e. its PFA)" (Savoli and Barki, 2013, p. 3) during the interaction with an IS. Hence, PFA can trigger user's actions, determining the respective outcomes based on IS use. Thus, PFA can enable or prevent the desired outcomes of the IS use (Savoli and Barki, 2013). Several prior studies underline the importance of examining PFA on an individual level by triggering affordances in reference to the personal goals of each user in order to reach the desirable outcome (Volkoff and Strong, 2013; Strong et al., 2014).

2.3 The role of goals in behavior change interventions

The key point of the PFA is the goal-oriented action process that is responsible for perceiving the possibilities of an IS for each user (Savoli and Barki, 2013). Individual behavior changes – as one goal of persuasive systems – are also described as calculated, goal-directed processes in which the individual must perform various actions to achieve the intended goal (Heckhausen and Gollwitzer, 1987). According to the transtheoretical model of change (DiClemente and Prochaska, 1998), behavior change is described as “a process in which individuals actively invest effort in setting or activating goals, developing and enacting strategies to achieve these goal, appraising process, revising goal and strategies according” (Bamberg, 2013, p. 152). In reference to the model of action phase (Heckhausen and Gollwitzer, 1987) the first and most pivotal task in behavior-change processes is creating a goal intention. In case of sustainable behavior, this task is often conflicted because the different individual needs and goals seem to differ strongly (e.g., the choice between convenient or environmentally friendly travel) (e.g., Bamberg, 2013; Lindenberg and Steg, 2007). In this relationship, Lindenberg und Steg (2007) developed the goal-framing theory to study how individuals can be motivated to shift their behavior towards greater sustainability although conflicts in goals exists.

The general assumption of this theory is that user’s goals, as mental constructs, must be activated in order to influence behavior (Lindenberg and Steg, 2007, 2013). Cognitions and motivations are unified in overarching goals (e.g., Moskowitz and Grant, 2009). When overarching goals are activated, the cognitive processes guide our attention, brain activity, as well as the selection and processing of information (Förster et al., 2005; Gollwitzer and Bargh, 1996). Thus, these cognitive processes affect motivation by inhibiting other goals, influencing fondness, and governing the criteria we use to assess whether a goal can be realized (Carver and Scheier, 2002; Ferguson and Bargh, 2004). Steg et al. (2014) distinguish between three overarching goal frames: hedonic, gain, and normative. When a hedonic goal frame is activated, people are attentive to factors that affect, e.g., their moods, feelings, energy levels, and atmosphere. This is relevant as several theories demonstrate the influence of affects and emotions on motivation and behavior (e.g., Nayum and Klöckner, 2014; Rezvani et al., 2015; Zhang, 2013). The aim of the gain goal frame is to protect and increase individual resources. Activation of this goal frame causes one to select information related to costs and benefits according to scarce resources. Hence, rational choice theories, such as the theory of planned behavior (Ajzen, 1991), are often applied to predict such behavior. People who activate the normative goal frame act for the public welfare, disregarding costs or hedonic aspects. The fundamental theory of the normative goal frame, the norm-activation model (Bamberg and Schmidt, 2003), focuses on normative concerns and was originally developed to explain altruistic behavior (e.g., Hopper and Nielsen, 1991).

According to the goal-framing theory, interventions are more effective when the activated goal is addressed in the given situations (Steg et al., 2014). Generally, there are two basic strategies for encouraging sustainable behavior. First, the expected outcome of sustainable behavior can be changed before the individual performs an action (Steg et al., 2014). As sustainable behavior is often associated with high costs and efforts, this behavior is rendered undesirable when the gain and hedonic goal frames are not supported (Steg et al., 2014). The second strategy aims to strengthen the normative goal frame through situational cues and the activation of special norms (Steg et al., 2014). Several studies have indicated that observations of norm-violating behavior increase the likelihood of personal norm-violating behavior (e.g., Cialdini, 1990). Therefore, situational cues showing other people breaking norms with their behavior weakens the individual’s normative goal frame and their striving to further satisfy their gain and hedonic goal frames (Keizer et al., 2008). However, situational cues can also encourage individuals to act more norm compliant based on positive observations (Keizer et al., 2008).

Previous studies have shown that hedonic and gain goals could support the normative goals because sustainable behavior can increase the status of an individual and result in positive emotions (Noppers et al., 2014; Venhoeven et al., 2013). Therefore, Steg et al. (2014) suggest that interventions successfully encourage sustainable behavior when hedonic and gain goals are also triggered, as long as normative goals are supported. Therefore, hedonic and gain goals must be linked to normative goals (Steg et al., 2012, 2014). However, the effectiveness of multiple goal frames on sustainable behavior has not yet been proven and must be further examined (Steg et al., 2014).

3 The Impact of Goal Frames and Affordances in Persuasive Systems on Bike Usage

In this study the desired sustainable behavior is heavy bike usage, measured by the distance traveled in kilometers. According to the goal-framing theory, only the activated normative goal frame leads to increased bike use over time (Lindenberg and Steg, 2007). However, as mentioned above, recent studies on the goal-framing theory indicate that the combination of hedonic or gain goals and the normative goal frame can further increase the willingness to behave more sustainably –in this case, to travel a greater distance by bike (Steg et al., 2012, 2014). In this regard, previous studies have point out the importance of further research to investigate which combination of activated goal frames result in sustainable behavior (Steg et al., 2012, 2014). Therefore, we address the following research question:

RQ 1: Which combination of the hedonic or gain goal frame with the normative goal frame results in heavy bike usage?

To analyze the motivational process of a gamified persuasive system on bike usage, we use the goal-framing theory in combination with the concept of functional affordances. In this study we understand a gamified persuasive system as an intervention to encourage sustainable mobility behavior. As mentioned above, the goal-framing theory acts on the assumption that two basic strategies for intervention exist to encourage sustainable behavior. We assume that these strategies can also be applied by gamified persuasive systems. Moreover, we suggest that bike use can be encouraged if the implemented functions of the gamified persuasive system change the expected outcome of riding a bike (Steg et al., 2014). For example, a function displaying the money saved by cycling leads to a change towards the perceived costs and efforts of biking. Consequently, the gain goal frame is activated alongside the normative goal frame (Steg et al., 2014). Furthermore, the functions of the gamified persuasive system can be applied as situational cues that indicate whether other people are complying with norms, which also influences the individual's behavior as discussed above (Keizer et al., 2008). For example, ranking lists offer the possibility of observing one's own performance in comparison to the performance of others.

This idea is basically in line with the assumption of the concept of perceived functional affordances, where the interaction with a gamified persuasive system can trigger certain actions and thus determines the desired outcomes (Savoli and Barki, 2013). However, this proposition must be put in perspective because – according to the concept of affordances – the implemented functions of a gamified persuasive system are only perceived and used if the user's pursued goals supply the desire affordances (Pozzi et al., 2014). Therefore, it is possible that individuals only use functions that are in line with their pursued goals and thus the activated goal frame. Hence, individuals pursuing a hedonic goal will probably never use the functions associated with the normative goal frame. To verify this assumption and clarify the interaction of pursued goals and activated goal frames on function usage as well as its effect on bike usage, we address the following research questions:

RQ 2: Do participants only use functions according to their pursued goal?

RQ 3: How do the used functions of the gamified persuasive website moderate the impact of the various pursued goals on bike usage?

The following figure illustrates the research model.

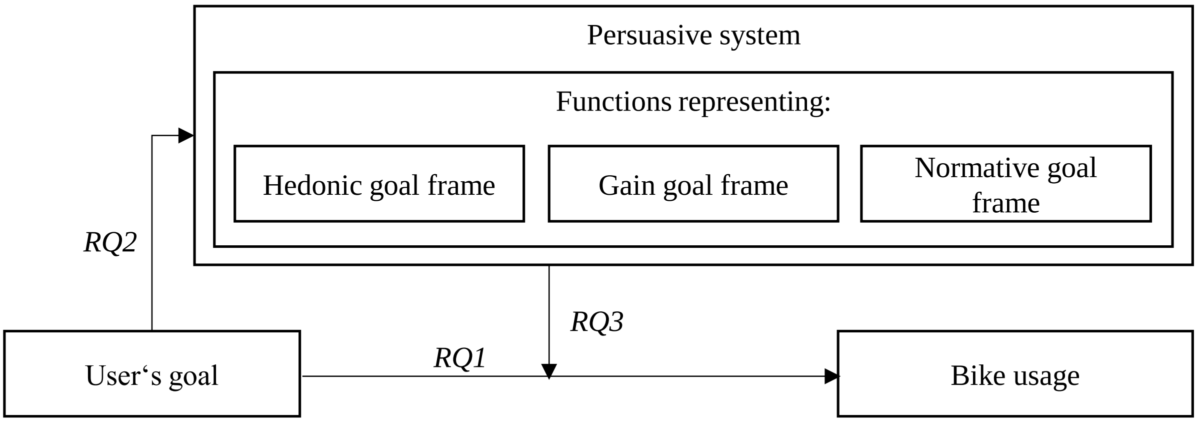

Figure 1. Research model.

4 Research Design and Method

4.1 Attribution of goals and functions to goal frames

It is assumed in this study that a goal frame is active when the participants pursue one specific goal, which can be assigned to a respective goal frame. The goals are supported by the design of the initiative's website with a variety of graphics, functions, and information. The assignment of the goals and functions is based on existing literature in the domain of persuasive systems and the goal-framing theory (Blohm and Leimeister, 2013; Lindenberg and Steg, 2007). Table 2 illustrates the attribution of the system functions to the user's concrete goals and the respective goal frame classification.

Goal frame	Participant's goals	Functions of the website
Hedonic	Self-exploration	Documentation of own behavior: Participants can fill out a calendar (time and distance traveled per day).
	Competition	Ranking list: Participants can compare themselves to the team performance. Furthermore, the participants can compare the performance of their team with the performance of other teams within the commune and the performance of their commune with the performance of other communes.
	Collaboration	Group tasks: The participants take part in a team within their related commune. The participants can use social media functions to communicate with each other.
Gain	Cost reduction, health promotion	Display of mileage.
Normative	Climate protection	Displays CO_2 savings.

Table 2. User goals and the website functions in the respective activated goal frames.

As illustrated in Table 2, the gamified persuasive website studied implements several designs to address the two above-mentioned strategies for encouraging sustainable behavior (Steg et al., 2014). First, the website aims to change the expected outcome of cycling by visualizing, e.g., a high position within the ranking list as a result of heavy bike usage to satisfy hedonic and gain goals (Steg et al., 2014). Second, the website with its various functions can be understood as a situational cue for norm activation. For example, a participant might notice that other participants in the team are acting norm compliantly and satisfying the normative goal frame, leading him or her to overthink his or her actions and triggering the willingness to change his or her behavior. Therefore, the designers try to encourage the normative goal frame through the well-applied conjunction of functions supporting the gain, hedonic, and normative goal frames.

4.2 Sample and data-collection procedure

The use of the website is voluntary and took place over a 21-day period between May and September 2014. The starting point was chosen independently by each local commune. The teams were self-selected and self-organized within their respective communes. We asked all participants (*N* = 86,000) of the initiative via e-mail to fill out a 15-minute online survey in three instances over the total timespan. The first survey was due three days before the initiative began for their commune. The second was to be submitted one week into participating in the initiative and the third one month after the initiative ended. All three surveys were completed by 973 participants. However, we only considered active participants who used the website more than 5 times a week, leading us to a final sample of 248 participants.

The first questionnaire contained inquiries concerning age, gender, household size, related commune, mobility possibilities in their household, highest education, and date of birth. The age within the sample ranges from 17 to 78 years (mean: 47 years) with a 40% share of females. Most of the participants live in a two-person household (32%), followed by nearly equal distributions of one- (21%), three- (19%), and four-person (20%) households. Only 6% of the participants live in a household with 5 or more people. More than half have a university degree (51%), while 12% have a general qualification for university entrance and 20% have a general certificate of secondary education. Furthermore, the first survey contained single-choice items (Haladyna and Rodriguez, 2013) with preset dichotomous options (no [1] or yes [2]). Each goal that initiated participation in the initiative was listed separately (second column of Table 2). The participants could decide whether each goal was relevant to them. Table 3 illustrates the participant's goals in accordance with Table 2.

	Participant's goal	**Numbers of participants (%)**
Hedonic goal frame	Collaboration (H_Col)	29 (11%)
	Competition (H_Com)	77 (31%)
	Self-exploration (H_Sel)	72 (29%)
Gain goal frame	Cost reduction (G_Cos)	66 (27%)
	Health promotion (G_Hea)	183 (74%)
Normative goal frame	Climate protection (N_Cli)	148 (60%)

Table 3. Participants' goals.

In the second survey, the participants were asked to answer a multiple-choice question with interval-scaled preset options about their average frequency of website use in general as well as the functions they used on the website per week (see third column of Table 2). The participants could choose between the following options: never, 1–2 times, 3–4 times, 5–6 times, 7–8 times, 9–10 times, and more than 10 times. In all three surveys the participants had to specify their mobility behavior in order to analyze the development during the initiative. Hence, we could calculate the distance traveled by bike in kilometers for each participant.

4.3 Statistical analysis in reference to the research questions

We used SPSS Version 23.0 to analyze the data gathered. The data cleaning and calculation took place in three steps: First, the structure and distribution of the data was analyzed and verified with the aid of descriptive statistical approaches to identify outliers and failed data records. In the second step, we proved the requirements of the analysis of covariance (ANCOVA; Huitema, 2011), i.e., the normal distribution of the dependent variables (DVs) with a histogram and a Gaussian distribution curve as well as the homogeneity of the variance using the Levene test (Levene, 1960). Afterwards, we tested the research questions with the ANCOVA across various random factors. The ANCOVA analyzes whether the sample mean of a DV, i.e., frequency of function usage (*RQ 2*) or total distance traveled by bike in kilometers (*RQ 1*; *RQ 3*) are the same across all levels of a dichotomous independent variable (IV), i.e., activated goal (all *RQs*) and function usage (*RQ 3*). While calculating the ANCOVA, the impacts of other irrelevant variables on the DV were statistically controlled. This means that the part of the variance explained by the irrelevant variables regarding the error term was removed, thereby yielding a more powerful test (Huitema, 2011). Because some participants had more than one goal, we had to control the impact of the other irrelevant goals and used functions for the examined case to study the impact of the specific goal on both function usage (*RQ 2*) and bike usage (*RQ 1*). For the analysis of *RQ 3* both functions as well as goals were controlled. For *RQ 3*, the frequency of function usage was applied as an independent variable and therefore had to be transformed to a dichotomous variable. Hence, the function use of less than five times per week was coded with “1” and five times or more was marked with “2”.

5 Results

First, the structure and distribution of the data was analyzed and verified with the aid of descriptive statistical approaches. There were no invalid records from missing data. Due to page limitations, only the nearly significant ($p \leq .10$) and significant ($p \leq .05$) results are presented in the following paragraph. The first requirement of the ANCOVA, the normal distribution of the DVs, i.e., bike usage and frequency of function use, is proven successfully. Table 4 illustrates the results of the Levene test (Levene, 1960) as the second requirement of the ANCOVA by analyzing the homogeneity of the variance. The non-significant deviation of homogeneity of the variance is given in most cases.

RQ	Goal(s) (function)	F-value	dfe	dfs	*p*-value
RQ 1	H_Com and N_Cli	2.649	3	244	0.050
RQ 2	H_Com (Ranking)	0.831	1	233	0.363
	H_Com (Display of mileage)	0.146	1	233	0.702
	H_Com (Documentation)	1.425	1	245	0.234
	H_Com (Group task)	1.289	1	228	0.257
	H_Sel (Ranking)	0.456	1	233	0.500
	N_Cli (Display of CO_2 savings)	5.323	1	228	0.022
RQ 3	H_Sel (Ranking)	3.033	3	244	0.030
	H_Com (Rankings)	1.440	3	244	0.232
	N_Cli (Ranking)	3.045	3	244	0.029
	N_Cli & H_Coll (Display of CO_2 savings)	0.569	7	240	0.780
	N_Cli & G_Hea (Display of CO_2 savings)	2.187	7	240	0.036
	N_Cli & G_Cos(Display of CO_2 savings)	0.769	7	240	0.614

dfe= Degrees of freedom regarding the effects; dfs= Degrees of freedom regarding the sample size.

Table 4. Results of the Levene test.

To prove the impact of the interaction between the activated normative goal frame and a specific gain or hedonic goal frame on the distance participants traveled (*RQ 1*), we employed the ANCOVA. The calculations show that the activated hedonic goal frame interacts with the normative goal frame in a nearly significant manner ($F(1, 247) = 2.80$, $p = .096$). The activation of both the normative and hedonic goal frames via the concrete goals “competition” and “climate protection” led to a greater distance traveled than the activation of a single or no goal frame. Table 5 displays the results of first-order interaction effects between different goal frames (*RQ 1*).

	With an activated H_Com	**Without an H_Com**
With an activated N_Cli	57.24 (44.12)	38.79 (34.33)
Without an activated N_Cli	40.67 (35.77)	45.12 (36.14)

Table 5. Results of the interaction effects of the ANCOVA (RQ 1; N *= 248).*

The between-subjects analysis of the participants’ function usage with and without a specific pursued goal (i.e., hedonic, gain, or normative) were also examined with the ANCOVA while the other specific goals were controlled (*RQ 2*). The results show significant main effects of the activated hedonic goal “competition” on the use of the ranking list function (F(1, 246) = 28.98, p = .000) as well as the mileage display function (F(1, 246) = 10.17, p = .002). The functions “ranking list” and “display of mileage” were primarily used by participants with the active hedonic goal “competition.” Furthermore, the pursuit of this goal appears to lead to an increased use of the documentation function (F(1, 246) = 2.70, p = .100) as well as the group task function (F(1, 229) = 3.29, p = .071) to a nearly significant degree. Hence, participants with the activated hedonic goal “competition” used both functions more often. Table 6 illustrates the results of *RQ 2* regarding the activated hedonic goal “competition.”

Function usage	**With activated H_Com**	**Without activated H_Com**	**F-Value (*p*-Value)**
Ranking list	4.1 (1.68)****	2.95 (1.59)****	28.98 (.000)
Display of mileage	5.03 (1.92)***	4.39 (1.28)***	10.17 (.002)
Documentation function	4.88 (1.26)*	4.64 (1.11)*	2.70 (.100)
Group task function	3.37 (1.86)*	3.04 (1.64)*	3.29 (.071)
****$p \leq 0.001$; ***$p \leq 0.01$; **$p \leq 0.05$; *$p \leq 0.10$.			

Table 6. Results of the main effects of the ANCOVA (RQ 2; N *= 248).*

Moreover, the pursued hedonic goal “self-exploration” has a nearly significant main effect on the use of the ranking list function (F(1, 234) = 3.57, p = .060). This goal resulted in an increased frequency of use of the ranking list function ($M_{with\_H\_Sel}$ = 3.49, SD = 1.67; $M_{without\_H\_Sel}$ = 3.27, SD = 1.73). Additionally, the pursued normative goal “climate protection” has a significant main effect on the use of the CO_2 savings display function (F(1, 229) = 13.25, p = .000). Here, the activated normative goal led to an increased use of this function ($M_{with\_N\_Cli}$ = 3.91, SD = 1.63; $M_{without\_N\_Cli}$ = 3.03, SD = 1.86).

In *RQ 3* we studied the effect of the interaction between the random factors “with and without a specific activated goal” and “with and without a specific frequent function use” on the distance participants traveled. We again used the ANCOVA in order to control for the other specific goals and functions. As a first significant first-order interaction, the pursued hedonic goal “self-exploration” was identified (F(1, 247) = 5.129, p = .024). This goal led to a reduced distance traveled if the participants used the ranking list five or more times a week. Contrastingly, frequent usage of the ranking list function or the sole pursuit of the hedonic goal “self-exploration” increased bike use. Furthermore, there are two nearly significant first-order interactions between the pursued normative goal “climate protection” as well as the hedonic goal “competition” with the frequent use of the ranking list function (hedonic: F(1, 247) = 2.67, p = .104; normative: F(1, 247) = 3.30, p = .071). Participants pursuing the hedonic goal “competition” or the normative goal “climate protection” and using the ranking list function five or more times a week had the highest values for distance traveled. Table 7 shows the first-order interaction effects for the various activated goals and the use frequency of the ranking list function on the distance participants traveled (*RQ 3*).

Activated goals	Ranking list use	No ranking list use	F-Value (*p*-Value)
With H_Sel	37.88 (22.73)**	47.42 (22.73)**	5.129 (.024)
Without H_Sel	51.85 (50.68)**	35.64 (38.21)**	
With H_Com	52.60 (47.60)*	32.73 (43.43)*	2.67 (.104)
Without H_Com	42.04 (39.31)*	40.16 (32.96)*	
With N_Cli	51.33 (52.40)*	35.08 (30.50)*	3.30 (.071)
Without N_Cli	41.24 (26.84)*	44.24 (41.35)*	
$^{**}p \leq 0.05$; $^{*}p \leq 0.10$.			

Table 7. Results of first-order interaction effects of the ANCOVA (RQ 2; N *= 248).*

The results also show two significant second-order interactions affecting the distance participants traveled (collaboration: F(1, 248) = 4.15, *p* = .043; gain: F(1, 248) = 4.35, *p* = .038). In this case, the pursuit of the normative goal "climate protection" in combination with the hedonic goal "collaboration" and the frequent use of the CO_2 savings display function increased the distance traveled ($M_{with\_H\_Col;\ with\_N\_Cli;\ with\_CO2}$ = 66.18, SD = 38.06; $M_{without\_H\_Col;\ without\_N\_Cli;\ without\_CO2}$ = 40.84, SD = 28.00). In contrast, the pursuit of the normative goal "climate protection," the gain goal "health promotion," and the frequent use of the CO_2 savings display function led to a lower distance traveled ($M_{with\_G\_Hea;\ with\_N\_Cli;\ with\_CO2}$ = 39.52, SD = 33.74; $M_{without\_G\_Health;\ without\_N\_Cli;\ without\_CO2}$ = 51.20, SD = 19.34). A further second-order interaction between the pursued normative goal "climate protection," the gain goal "cost reduction," and the frequent use of the CO_2 savings display function emerged with only near significance (F(1, 248) = 2.84, *p* = .093). Here, the two goals pursued and the frequent use of the display of CO_2 savings function decreased the distance traveled ($M_{with\_G\_Cos;\ with\_N\_Cli;\ with\_CO2}$ = 36.73, SD = 27.36; $M_{without\_G\_Cos;\ without\_N\_Cli;\ without\_CO2}$ = 46.04, SD = 37.77).

6 Discussion

This study analyzes the motivational process of a gamified persuasive system, which was developed as part of an initiative aiming to motivate individuals to get involved with sustainable mobility behavior through promoting bike use. In this respect, we are first interested in the compatibility of the participant's goals with the functions implemented. Here, the measurements regarding *RQ 2* indicate that there do exist single suitable functions to support the pursued hedonic goals "competition" and "self-exploration" as well as the normative goal "climate protection". The data is partially in line with the assumption of the concept of affordance, in which the features of an artifact and the participants' goals generate the user's affordances, thereby influencing the use and perception of the IS (Pozzi et al., 2014).

As expected, participants pursuing the normative goal "climate protection" frequently used the designated function "display of CO_2 savings". However, while participants with the goal "competition" often used the ranking function, they also regularly used the functions "display of mileage", "documentation", and "group task", which were not originally designed for this purpose. This holistic impact of the goal "competition" on function usage could be explained by the fact that the other functions, i.e., "display of mileage", "documentation", and "group task" may also provide information about one's own status, which is necessary for a competition with other participants.

Furthermore, unexpectedly, participants with the pursued hedonic goal "self-exploration" used the ranking list function more often than participants without this goal did. The ranking list function may offer the possibility to observe one's own behavior in comparison to others. Such information could be more interesting for self-exploration than information about the time and location of bike usage offered by the documentation function, which was originally designed to support this goal.

Moreover, the pursued hedonic goal "collaboration" as well as the gain goals "health promotion" and "cost reduction" do not determine the function use. These findings could be a result of the gamified persuasive system design. The display of mileage function should support the two gain goals; however, this function requires calculations made by the participants in order to draw conclusions about the health promotion and cost reduction effects of bike use. Hence, these functions require additional effort from the participant in contrast to the other functions. This circumstance could cause a misfit between the participant's pursued goal and both offered functions. Furthermore, to satisfy the hedonic goal "collaboration", the persuasive system offers a link to popular social media applications and a message function allowing participants to communicate with their team members. According to the data about function usage, the participants with the concrete goal "collaboration" might have favored the idea of being part of a team over the option of communicating with their teammates via a message service.

These findings make the assumption of Blohm and Leimeister's (2013) about the relationship between game-based functions and their addressed needs and goals debatable (see Table 1). They suggested that the goal "competition" is supported by the ranking list function and that the "self-exploration" goal is satisfied by the documentation function. However, at this point we do not argue that this assumption is wrong. It merely shows that the success of theoretically appropriate implementation of a mechanism depends on individual needs and the technical implementation in regards to user's affordances and usability.

This findings underlines the importance of a user-centric approach for IS design, meaning that the functions should be developed in reference to the users' goals and needs (Gabbard et al., 1999). Additionally, the fit between goals, needs, and functions should be continuously evaluated in course of the artifact-development process (Peffers et al., 2007). Moreover, future research investigating the relationship between a user's goals and function usage of other artifacts in different contexts is needed. Our approach is based on the assumption of the theory of affordances, in which both the features of an IS as well as user goals determine the function usage. Nevertheless, previous IS studies have indicated that further factors such as emotions (e.g., Beaudry and Pinsonneault, 2010), personal characteristics (e.g., Sun et al., 2008), and technology types (e.g., Wang and Scheepers, 2012) play a role in determining the use of an artifact. Therefore, there could be further variables that are relevant for the participants' function usage but are not investigated in this study; they should be considered in future research.

Another objective of this study is to examine the relationship between an individual's goals, used functions, and the initiative's desired sustainable behavior outcome. To do so, we determined how a combination of contradicting goal frames can lead to heavy bike usage. The findings of *RQ 1* are in line with the assumption that the effectiveness of sustainable behavior could be further increased if multiple goal frames were activated (Steg et al., 2012, 2014). The activation of the normative and hedonic goal frames via the concrete goals "competition" and "climate protection" results in higher values for distance traveled than the activation of one or none of these goal frames as previous studies indicated. Nonetheless, to the best of our knowledge, the application of single cues to satisfy one or various goals and thus leading to sustainable behavior has not yet been studied in behavioral science or IS research (Steg et al., 2014). In this case, more research is needed to determine how these goals could be linked to each other – e.g., with functions within a persuasive system to increase sustainable behavior.

This research gap is addressed in *RQ 3* by the impact analysis of the effect of the participants' pursued goals and functions used on distance traveled. Our findings indicate that the combination of either the normative goal "climate protection" or the hedonic goal "competition" with the frequent use of the ranking list function can lead to the greatest distance traveled. This result highlights the importance of the ranking list function for encouraging sustainable behavior. However, designers should be cautious in applying ranking lists in persuasive systems. In this scenario, participants with the pursued hedonic goal of "self-exploration" and the frequent use of the ranking list function had a lower distance traveled than participants with either a frequent use of the ranking list function or the sole activation of the hedonic goal "self-exploration". As suggested above (*)*, ranking lists allow the user to perceive his or her own behavior in reference to others. While this information is probably more valuable than the information regarding the time and location of bike usage offered by the designated documentation function, it could also cause social pressure. This assumption is based on the self-determination theory (SDT; Deci and Ryan, 1985) which is also applied in studies of persuasive system design. The SDT suggests that autonomically determined behavior leads to a more persistent behavior change than extrinsically determined motivation, in terms of pressure (Deci and Ryan, 1985). Furthermore, prior studies about game-based persuasive systems have shown that the motivational effect of ranking lists is inconsistent. While ranking lists lead to positive behavior changes in some contexts, they fail in others – sometimes even resulting in negative effects due to demotivation or the fear of failure and public exposure (Christy and Fox, 2014; Codish and Ravid, 2014; Domínguez et al., 2013). The different impact of ranking lists on behavior regarding the pursued goals identified in this study could be a possible explanation for the inconsistent findings about the effectiveness of ranking lists in previous investigations. Therefore, the consideration of such precarious functions should be taken carefully into account in persuasive system design. In this relationship, designers might consider peculiarity of user's goals when implementing ranking lists in persuasive systems in order to encourage sustainable behavior.

The results also suggest that the pursued normative goal "climate protection" in combination with the hedonic goal "collaboration" and the frequent use of the CO_2 savings display function increases the distance traveled. In contrast, the pursued normative goal "climate protection", the gain goal "health promotion" or "cost reduction", and the frequent use of the CO_2 savings display function led to lower distances traveled. In this regard, previous studies have indicated that interventions should trigger the hedonic goal frame instead the gain goal frame in combination with the normative goal frame to successfully reach sustainable behavior (Steg et al., 2012). The findings confirm this assumption –, but further research is needed to determine the impact of different goals on sustainable behavior moderated by the functions studied in controlled settings.

The study poses some limitations that should be considered when using these results to validate the theories and practical implications applied within. The measurement of the constructs is based on self-reports and not measured by objective data. Moreover, a clear operationalization of how the respective goal frames are activated is necessary to further elaborate the true impact of combined activated goal frames on sustainable behavior. In this regard, further research for the development of suitable measurements for activated goal frames is required. In this relationship, we suppose that the participants are conscious of their goals before the initiative starts. Furthermore, we suggest that the pursued goals are responsible for the activation of specific goal frames and assign single pursued goals to each goal frame. This assignment is based on existing literature, but the connection is still unexplored; however, a first attempt on this matter is made in this study. In addition, the main effects and interactions calculated are only nearly significant ($p \leq .10$) in some cases. Furthermore, in four cases the second requirement of the ANCOVA, i.e., homogeneity of the variance, is not fulfilled. Additionally, no control group is considered to allow for a comparison of the distance traveled without a persuasive system.

7 Conclusion

Summing up, we can state that the functions implemented are partially compatible with user goals. The functions studied are not suitable for triggering the gain goal frame in this scenario, unlike the hedonic goal "competition" and normative goal "climate protect". Furthermore, the results reveal that a combination of the hedonic goal "competition" and the normative goal "climate protection" leads to a positive impact towards sustainable behavior. We could show that the impact of the hedonic goal "competition" as well as the normative goal "climate protection" on sustainable behavior is moderated by the function of ranking list. Furthermore, the implementation of the CO_2 display function is critical if the participants pursue the normative goal alongside the gain goal "cost reduction" or "health promotion". However, additional investigation is needed to validate the results concerning the impact of pursued goals and functions used on diverse desired behaviors – particularly in different contexts.

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