Green gamification: How gamified information presentation affects pro-environmental behavior

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Abstract. Although most people believe that climate change and sustainability are important problems, too few actively engage in pro-environmental behavior. Why is that? The psychological distance to the consequences of climate change is too high. Therefore, people have the perception that their actions do not affect climate change. Drawing on construal level theory, this research examines whether gamified information presentation (i.e., providing information in the form of a game with visual or numerical feedback) enhances pro-environmental behavior by reducing the psychological distance. Results from an online experiment with a follow-up survey reveal that visual feedback increases pro-environmental behavior through perceived vividness, while numerical feedback works through perceived information quality. These findings advance the understanding of the psychological outcomes that govern how people respond to receiving environmental information in the form of gamification. Further, they provide important practical implications on how policy makers might use gamified information presentation to nudge pro-environmental behavior.

Keywords: Gamification, Gamified Information Presentation, Pro-Environmental Behavior, Sustainability, Construal Level Theory, Psychological Distance.

1 Introduction

The United Nations state that "climate change is the defining issue of our time [1]." Due to global warming, food production is threatened, and the risk of catastrophic flooding is rising. Increased carbon dioxide emissions are one of the main reasons for global warming. The rise of these emissions is largely man-made. Therefore, humans have to change their behavior drastically to ensure a sustainable life on earth [1]. Recently, a shift in thinking has occurred amongst a broad population: Most people have a pro-environmental attitude. Unfortunately, although the majority of individuals are environmentally conscious, they do not behave in such a way. This can be explained by psychological barriers that impede such behavioral choices [2]. Individuals often have a high psychological distance to the effects of global environmental problems because the consequences of climate change have no immediate effect on people's own lives [3].

Currently, there is a multitude of approaches to enhance pro-environmental behavior. However, these interventions are usually not very successful since many of these

actions attempt to just educate people with information about the problems of global sustainability [4, 5]. This information indeed raises general concerns about the environment but doesn't trigger behavioral change, as it is perceived as complex and uninteresting [6]. Therefore, interventions that reduce the psychological distance to the consequences of environmental problems and elicit an actual shift in behavior are needed.

I suggest that gamification has the potential to address these challenges. Gamification has emerged as a technological trend that transfers the features of games to non-game contexts [7, 8]. Studies in different fields, such as health, education, and marketing, have already shown that gamification influences people's behavior [9]. However, the few studies in the field of sustainability do not provide conclusive findings on whether gamification affects actual pro-environmental behavior [4, 5, 10].

Hence, this research aims to understand whether and how gamification can increase pro-environmental behavior. In order to reach this goal, first, I draw on one of the defining traits of games – immediate feedback [11]. Games and gamification provide information in terms of feedback, which is a response to past behavior and directly reflects the consequences of one's actions [12]. Second, based on construal level theory (CLT), I argue that the psychological distance should be reduced by the gamified information presentation (i.e., providing information using a game) because the feedback makes the effects of own behavior more vivid and helpful [13]. CLT posits that people act differently based on their perceived psychological distance and that low psychological distance induces people to become active [14, 15]. Therefore, I posit that gamification in terms of gamified information presentation can enhance pro-environmental behavior due to the reduction of psychological distance. Thus, the gamified information presentation should increase perceived vividness and information quality which accordingly should encourage pro-environmental behavior.

I conducted an online experiment with a follow-up survey two weeks later, combined with a diary approach. In the experiment, the subjects were confronted with daily decisions that affect their carbon dioxide emissions differently. An effective total of 450 subjects took part in the study. Each participant was facing either one of three different types of gamified information presentation (visual feedback, numerical feedback, visual and numerical feedback combined) or no gamified information presentation, where the subjects received the same information, but not in the form of personal feedback on their own actions. The results of seemingly unrelated regressions provide evidence that gamified information presentation enhances pro-environmental behavior. While visual feedback works through increased vividness, numerical feedback enhances perceived information quality.

The contribution of this paper is threefold. First, by examining the relationship between gamified information presentation and pro-environmental behavior, this study expands the previous literature on gamification and sustainability [e.g., 4, 10]. Second, by drawing on CLT and psychological distance, this study brings a new theoretical perspective on how gamification motivates behavior [9]. Third, the insights into the effect of gamification and the different types of gamified information presentation on pro-environmental behavior are valuable for policy makers and environmental organizations, as they reveal an effective intervention on how to nudge people towards more sustainable behavior.

2 Conceptual framework

2.1 Gamification and pro-environmental behavior

Gamification aims to transfer features of games to non-game contexts in order to evoke a gameful experience [7, 8]. Accordingly, a user should perceive a gamified situation or an interaction with a gamified service similar to playing a game even if in a serious context [9]. To accomplish this, gamification is based on the "ludus" concept [7]; i.e., the fundamental characteristics of games like goals, rules, structure, and feedback should be transferred into the non-game context [11]. Through these components, gamification presents and conveys information differently. People take an active part in the presentation of information and experience information in a gameful way. Hence, using a game or game elements to convey information refers to *gamified information presentation* [13]. I emphasize that feedback is key to perceiving and processing information differently from conventional forms of information presentation. Feedback gives people direct information about their individual behavior which makes it more likely that they modify their future actions [12]. More precisely, in games, people receive concrete and immediate information about the consequences of their choices and what might have happened with alternative decisions. This helps them to reflect on their behavior and shows how changes in behavior might have a relevant impact [16]. Literature on information presentation often distinguishes between visual and numerical feedback. *Visual feedback* describes the animation that reacts to the behavior or decision of the user in a game: A dynamic change of graphics, color schemes, and other visual stimuli takes place [16]. *Numerical feedback*, on the other hand, gives people feedback on actions by using numbers. Various numerical formats exist to represent information, such as percentages or odds [17]. Games often use both types of feedback.

In light of growing environmental problems, the scientific discussion of approaches to promote pro-environmental behavior is increasing. *Pro-environmental behavior* refers to actions that consciously aim to minimize the negative effects of one's actions on nature [18]. This includes a wide variety of activities. Previous studies in gamification literature mostly focus on energy consumption [4, 5, 10]. While the studies predominantly imply that gamification has a positive effect on the intention to reduce energy consumption, the effect on actual pro-environmental behavior is uncertain due to opposing results [e.g., 4, 10]. To examine this relationship, this study utilizes the paradigm that raising awareness of the effects of personal actions can contribute to changed intentions and behaviors [12]. For this reason, this study focuses on gamified information presentation in which feedback has a decisive role in conveying information. I draw on CLT to explain how differences in giving and processing information affect behavior.

2.2 Construal level theory

The CLT by Trope and Liberman [14] is an influential approach on how psychological distance influences individuals' thoughts and behaviors. The theory differentiates between a high and a low level of construal. CLT assumes that people mentally construe situations that are psychologically close in terms of low-level, detailed, and contextualized features, rather than at a distance where they construe the events in terms of high-

level, abstract, and stable characteristics. Research has shown that different dimensions of psychological distance (time, space, social, and hypothetical) influence one's mental construal which in turn guides prediction, evaluation, and behavior [14]. People regularly have a high psychological distance to climate change. For example, people in Europe have a high construal regarding a persistent dry season in Africa as a consequence of climate change because of the spatial distance. Also, in most cases, the effects of current environmentally harmful activities manifest decades later. This temporal distance leads to high levels of abstraction [2]. Such high psychological distance inhibits behavioral change [15]. The psychological distance of people should be detectable with constructs that represent ones' mental abstraction level, such as vividness and information quality.

Vividness of presentation describes a presentation of information that is characterized by clarity and liveliness. Perceived vivid information is emotionally appealing, imaginary-provoking, and causes sensory, temporal and spatial proximity [19]. It should be noted that vividness is not a stimulus but represents the reaction of individuals to stimuli. Since vivid information or events appear concrete, this corresponds to low-level construals and should be based on a low psychological distance [14, 15].

Information quality is assessed by the degree to which an information is perceived as helpful in completing a particular task [20]. Information quality is a multidimensional construct. The dimensions understandability, accuracy, relevancy, and appropriate amount of information appear to be particularly important in the context of (gamified) information presentation [21]. To educate people, the perceived understandability and accuracy of information is essential to reduce the complexity of content. At the same time, personally relevant content increases the attention of users and facilitates the absorption of information. An appropriate amount of information helps to process that information effectively with the available cognitive resources [22]. Consequently, it can be assumed that depending on the perceived information quality, individuals experience information or situations either concrete or abstract. At low-level construals, people perceive events as understandable and relevant, thus experiencing higher information quality [14].

2.3 Conceptual model

As mentioned before, the effects of climate change are abstract for many individuals [2]. I assume that with the use of gamification, the psychological distance decreases and the presented information is perceived as more vivid and of higher quality. The gamified information presentation in the form of different feedback types (visual feedback, numerical feedback, and visual and numerical feedback combined) simulate the impact of people's choices on the environment and thereby will reinforce first the intention of pro-environmental behavior and subsequently resulting in actual pro-environmental behavior through perceived vividness and information quality (see Fig. 1).

Based on the theoretical consideration of CLT, it can be expected that gamified information presentation will create a more concrete level of representation by giving feedback in various forms. This lower representation level will be reflected by increased perceived vividness and information quality [14, 15]. More precisely, visual feedback in games (e.g., animations or videos) directly conveys sensory information that allows a person to experience how their behavior affects the environment. Thus,

visual feedback can be used to simulate the consequences of one's behavior, which are very close to reality. This experience will ultimately increase the perceived vividness of presentation [13]. While the strength of visual feedback is the simplification and vividness of information, numerical feedback is particularly concrete and accurate [17]. Statistical information alone is often not meaningful for individuals, but numerical information in terms of feedback on one's behavior becomes more relevant for the individual. Further, with gamified information presentation, it is possible to give the appropriate amount of information and express them in a comprehensible manner [22, 23]. Thereby, numerical feedback will mainly increase the perceived information quality. A concrete level of representation via vividness or information quality goes hand in hand with a lower psychological distance and thus is associated with more intense behavioral responses [14, 15]. Ultimately, the strongest reactions can be observed with direct experiences. Hence, experience via simulation of the consequences of climate change with gamified information presentation should lead first to pro-environmental behavior intention and subsequently to actual pro-environmental behavior [13, 24].

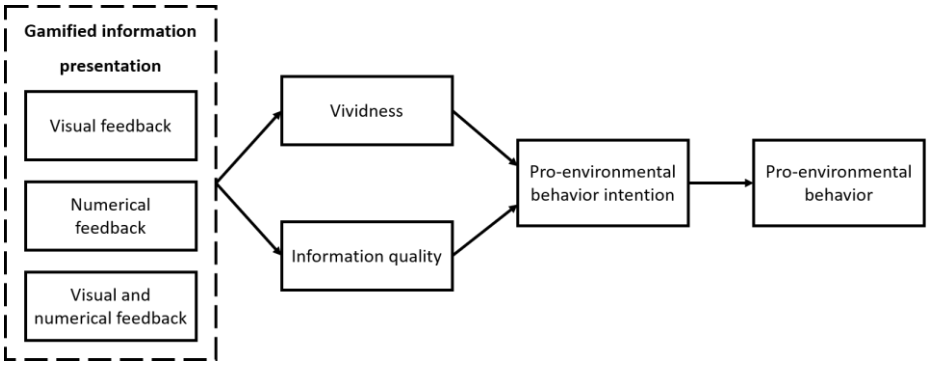

Fig. 1. Research Model

3 Method

3.1 Design, sample, and procedure

To test the research model, I used a one-factorial (visual feedback vs. numerical feedback vs. visual and numerical feedback combined vs. no gamified information presentation) between-subjects design. I collected data through an online experiment distributed via university channels and across social media. As an incentive for taking part, four vouchers, worth a total of $100, were raffled among all participants. I received 493 replies. Responses from participants who did not complete the experiment, finished in an unrealistic time, or answered click-through questions incorrectly were removed from further analysis, resulting in an effective sample of 450 respondents (66% female, M_{age} = 29) with 113 in the visual feedback group, 111 in the numerical feedback group, 122 in the combined visual and numerical group, and 104 in the no gamified information presentation control group. To assess their actual pro-environmental behavior, participants were invited to take part in a follow-up survey two weeks later. Therefore, a diary

approach was used to increase the reliability and validity of the answers [25]. Out of these 450 participants, 146 responded in the follow-up survey two weeks later. The participant distribution between the groups is similar to the initial distribution of the sample.

In the experiment, first, participants were introduced to the topic of the experiment and then rated their pro-environmental behavior for the last two weeks. Following, the subjects were instructed to imagine themselves in a typical student's day with nine routine tasks, ranging from showering in the morning, how they travel to the university to what they cook in the evening. Afterward, participants were randomly assigned to one of four scenarios: visual feedback, numerical feedback, visual and numerical feedback combined, or common information presentation. In the visual feedback scenario, participants were informed that they have to choose between options on how to carry out each of these nine routine activities. The participants were encouraged to base their decision on their behavior in their own lives. For example, in the shower routine, the subjects chose between a 15-degree Celsius (cold) and a 35-degree Celsius (warm) shower. Based on their decision, they received visual feedback after each activity in the form of a tree, which bloomed if the option selected generates less carbon dioxide emissions or decayed if a less sustainable choice was made. The development of the tree was dynamic and adapted after each answer. After all nine decisions were made, the full spectrum of how the tree could have developed was revealed. The numerical feedback scenario was identical to the visual one, except participants were given feedback in the form of a specific carbon dioxide emission figure, which was issued by the participants' choices. The total carbon emissions were summed up after each decision. Also, the participants were shown the emissions of the alternative choices and at the end of all nine activities, the minimum and maximum of the carbon emissions were displayed. The third scenario with visual and numerical feedback was a combination of the two previous scenarios. Accordingly, the course was the same and the subjects received feedback in the form of a changing tree and the number of caused carbon emissions. The last scenario with no gamified information presentation served as a control group. Here participants received the information about the different options on how to perform the nine daily routines and how many carbon emissions each option causes, but they didn't choose between them. Thus, the subjects didn't get specific feedback on the choices they make in their daily life. After the scenarios, participants answered questions concerning their perceived vividness, information quality, pro-environmental behavior intentions, and several control variables (e.g., demographics and specific behavior habits). In the follow-up survey, the participants answered questions about their pro-environmental behavior in the last two weeks based on their diary entries.

3.2 Measures

I used seven-point Likert scales (1 = "strongly disagree" and 7 = "strongly agree") to capture all items if not stated otherwise. I included the different gamified information presentation types as dummy variables based on the assigned group. I measured vividness using six items (e.g., "The presentation of the information brought concrete images or mental pictures to my mind."; [13]) and information quality using twelve items as it is a multidimensional construct (e.g., "The information is easy to understand."; [20,

21]). To allow for independent mediators, I used regression-based factor scores to capture vividness and information quality. To measure pro-environmental behavior intention and actual pro-environmental behavior, I adapted three items (e.g., "I (intend to) engage in environmentally friendly behavior."; [26]). Cronbach's alphas confirm high reliability for all constructs ($\alpha \geq .84$). To eliminate confounds, I included controls for individual-specific factors: previous pro-environmental behavior using three items [26], age, and gender using single-items. Additionally, I controlled for a potential self-selection bias by applying Heckman's two-step correction procedure [27]. Data and items are available upon request.

4 Results

I adopted seemingly unrelated regressions (SUR) to test the research model [28]. The SUR method allows the estimation of direct and indirect effects of different regressions simultaneously in order to assess mediation effects [29]. Table 1 presents the direct effects estimated by the SUR. The results show positive and significant effects of visual feedback and visual and numerical feedback combined on vividness in reference to no gamified information presentation. Numerical feedback alone has no significant effect on vividness. However, numerical feedback as well as visual and numerical feedback combined have a positive and significant effect on information quality, while visual feedback alone, in reference to gamified information presentation, has no effect on information quality. Further, both vividness and information quality show positive significant effects on pro-environmental behavior intention. Also, all gamified information presentation types (vs. no gamified information presentation) have positive and significant direct effects on pro-environmental behavior intention. Lastly, pro-environmental behavior intention shows a positive and significant effect on the actual behavior.

To test the indirect effects of gamified information presentation on pro-environmental behavior, I estimated direct and indirect effects simultaneously. I employed bootstrapped SUR (5,000 draws), building on an empirical sampling distribution of the indirect effects. The results provide significant evidence that visual feedback has a positive effect on pro-environmental behavior mediated by vividness ($\beta_1\delta_1\zeta_1 = .05$; 95% confidence interval [CI]: lower-level confidence interval [LLCI] = .01, upper-level confidence interval [ULCI] = .13), while numerical feedback has a positive effect on the actual behavior mediated by information quality ($\gamma_2\delta_2\zeta_1 = .03$; 95% CI: LLCI = .00, ULCI = .11). Visual and numerical feedback combined (vs. no gamified information presentation) show an indirect positive effect on pro-environmental behavior mediated by both vividness ($\beta_3\delta_1\zeta_1 = .05$; 95% CI: LLCI = .01, ULCI = .14) and information quality ($\gamma_3\delta_2\zeta_1 = .02$; 95% CI: LLCI = .00, ULCI = .07). Further, chi-squared tests cannot confirm that combined feedback in form of visual and numerical feedback increases the pro-environmental behavior more than visual or numerical feedback alone ($\chi^2(1) \leq 1.76$; $p > .05$).

Table 1. Results for the direct effects

	VIV		IQU		PEI		PEB	
Independent variable	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**
Constant	-.86***	.15	-.43*	.17	3.93***	.30	.65	.79
Gamified information presentation								
Visual feedback	.97***	.11	.01	.14	.54***	.16	.18	.22
Numerical feedback	.12	.14	.79***	.13	.51***	.16	.03	.21
Visual and numerical feedback	.92***	.11	.55***	.13	.44*	.18	.08	.22
Mediators								
Vividness					.21***	.06	.10	.10
Information Quality					.19**	.06	.07	.10
Pro-env. behavior intention							.22**	.07
Controls								
Age	.01	.01	-.01	.01	-.01	.01	.01	.01
Female	.39***	.09	.15	.10	.41***	.12	-.18	.16
Previous pro-environmental behavior					.27***	.05	.57***	.07
Heckman correction factor							.65	.79
Adj. R^2	.23		.11		.24		.49	

Notes. VIV, IQU, PEI, PEB refers to vividness, information quality, pro-environmental behavior intention, pro-environmental behavior. N = 450 (146) for the first three (last) equations. To account for heteroscedasticity, I estimated all models using robust standard errors.
* $p \leq .05$; ** $p \leq .01$, *** $p \leq .001$.

5 Discussion

The results of the study are meaningful for policy makers and environmental organizations searching for a tool to effectively nudge pro-environmental behavior. First and foremost, the results demonstrate that gamified information presentation (vs. common information presentation) can enhance pro-environmental behavior and thereby supports findings of previous studies showing that gamification can positively influence sustainable behavior [e.g., 4]. The effect can be explained by the reduction of psychological distance to the consequences of climate change, which is represented by increased perceived vividness and information quality. By giving visual and numerical feedback, gamification makes information tangible and expands one's perspective by the reflection of personal behavior. While visual feedback increases the vividness of information, people perceive higher information quality through numerical feedback. However, the results show additional direct effects for all types of gamified information presentation on pro-environmental behavior intention compared to conventional information presentation, implying further differences.

5.1 Research and practical implications

The findings are relevant for gamification research in general and for sustainability research in particular. First, by examining the impact of gamified information presenta-

tion on pro-environmental behavior in terms of different feedback types, the study expands the previous literature on gamification and sustainability [e.g., 4, 10]. The research responds to the call for more reliable and valid studies [5] by investigating actual pro-environmental behavior and not only the intention while simultaneously comparing the effects with common information presentation. Second, drawing on CLT and psychological distance, I introduce a new theoretical perspective on how gamification motivates behavior. While most gamification research applies traditional motivation theories, such as self-determination theory, goal setting theory or flow theory, CLT and the examined constructs of vividness and information quality can broaden the findings of psychological outcomes of gamification [9].

The findings suggest that public policy makers and environmental organizations should rely on gamification to enhance pro-environmental behavior. The high psychological distance of people towards the effects of climate change can be lowered by using gamification to alter information presentation and perception.

5.2 Limitations and further research

This research has some limitations that offer fruitful avenues for future research. In this study, the participants only received gamified information presentation at one point in time. It would be interesting to investigate how continuous feedback via a gamified app affects pro-environmental behavior. Although this study captured actual behavior over a period of two weeks, this does not indicate a long-term effect of gamification on pro-environmental behavior. Further, the results suggest that gamified information presentation triggers pro-environmental behavior intention through other psychological paths than perceived vividness and information quality. Future research could tap into other potential psychological outcomes, such as perceived playfulness.

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