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Methaporical Visualizations of Energy Saving Impact for Behavioural Change: A Goal-Framing Approach and Results from an Online Crowd Evaluation

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1. INTRODUCTION

One of the most common technology-enabled strategies for stimulating behavioural change for energy saving has been the provision of feedback on one's energy consumption. However, the design and effectiveness of consumption visualizations is not yet well understood, as can be seen from substantial differences in approaches and their impact on consumption [1]. While it is often assumed that providing feedback will automatically lead to a change in behaviour, effective visualization models need to consider differences between users, in terms of their environmental goals and values [2], and their needs with regard to consumption feedback [3]. The design of data-oriented visualizations has been most frequently explored (e.g. bar or pie charts), but there is a large class of users with a low data affinity who cannot easily understand abstract numerical energy consumption information [4]. Alternative approaches include the use of metaphors that visualize the impact of consumption by showing information of (eco-related) phenomena known from everyday life [1][5]. This paper describes the theoretically-grounded design and evaluation of metaphor-based visualizations of energy consumption impact within the EU-funded enCOMPASS project (Grant Agreement no. 723059.), providing initial evidence for the persuasive potential of the designed solutions.

2. APPROACH AND VISUALIZATION DESIGN

To address the described differences in user needs, a metaphoric visualization of consumption impact for stimulating energy saving has been developed. It is part of a mobile app that also includes a range of gamified incentives, and personalized recommendations for energy saving. In this paper, the metaphoric impact visualization is addressed. Departing from Goal Framing Theory [2] and users' motivations for using energy feedback systems [3], three main goals for using energy saving applications are distinguished: normative goals (e.g. protecting the environment), gain goals (e.g. saving money), and hedonic goals (e.g. enjoying saving energy). The impact visualization consists of three views that relate to each of these goals. The view relating to the user's most important energy saving motivation is displayed by default (based on data obtained from a sign-up form), but users can switch between views at any time. Each view depicts the energy savings obtained from the start of using the app to the current month. The *'save money' view* displays the amount of money saved on the electricity bill, visualized through the corresponding number of piggybanks filled with coins. The *'save the environment'* view displays the total amount of CO_2 that was not emitted as a result of the savings, visualized through the corresponding number of trees (where the number of kg's of CO_2 saved reflects a "typical" absorption capacity of a tree over a year's time). Until the capacity of a tree is reached, CO_2 clouds fill up the tree before a new tree is added. The *'enjoy saving energy'* view relates to the gamified achievements of the user. It depicts jars filled with candies corresponding to the points received for the achieved savings, including progress towards the next reachable badge. In each view, users can also move back and forth between the months to compare their progress.

3. FIRST EVALUATION IN AN ONLINE USER TEST

As a first assessment of the described visualization model the impact visualizations have been evaluated with European crowd workers on Amazon Mechanical Turk using two crowd tests. Thirtythree people completed the test for the monetary and the environmental, and 32 people for the hedonic visualization. In the beginning of the test for each visualization participants answered questions measuring their overall goal-related values with items from [6]. The evaluation focused on comprehension, pragmatic and hedonic quality [7], and perceived impact on the participant's motivation for energy saving. For each impact visualization the participants were presented with screenshots and associated evaluation questions. To illustrate the dynamics of the visualizations, we utilized animated gifs showing different consumption scenarios and provided instructions to the users to imagine themselves using this application in a specific context. The results have shown a high understandability of the applied metaphors for the monetary and environmental visualizations (73% fully or partially correct answers), with somewhat lower values for the hedonic visualization (56%). The relative amount of savings achieved was well understood in all three cases (85%, 73% and 78% correct answers, respectively). With respect to their overall hedonic and pragmatic qualities all three visualizations received similarly positive ratings, with some differences on the individual items (e.g. the monetary and hedonic views were perceived as somewhat easier to understand, while the environmental one was perceived somewhat more beautiful than the others). Most importantly, the measured perceived motivational effect of all three visualizations was relatively high (82%, 88% and 84% strongly or slightly agreeing, respectively). Furthermore, correlational analyses suggest that environmental and egoistic (e.g. wealth) values affect the impact of the different visualizations on the user's motivation to save energy. Finally, answers to open-ended questions revealed suggestions for improvement of individual aspects of the specific visualization designs.

4. CONCLUSIONS AND FURTHER WORK

Overall, the results suggest that the developed model for metaphorical visualization of the impact of energy savings was well-understood, motivating and liked by the users. In particular, the results suggest that grounding the visualizations in goal-framing theory is a promising way for designing persuasive, easy-to-understand energy consumption visualizations that target the awareness of energy consumption impact through metaphors from everyday life. The developed visualizations are currently being implemented as part of the enCOMPASS mobile app, which will be longitudinally evaluated in real-world pilots in three different European countries.

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