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STIMULATING ENERGY-SAVING BEHAVIOUR THROUGH ECO-FEEDBACK, ADAPTIVE GAMIFICATION AND PERSONALIZED RECOMMENDATIONS

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1. INTRODUCTION

The use of IoT technologies (e.g. smart metering, smart home) and persuasive techniques to support energy-saving behaviour in households has been increasingly researched. Studies suggest that effective designs of such systems should incorporate different types of feedback with motivational techniques and energy saving advice [4]. But to be effective, these must consider different consumer types and needs, be presented at the right moment and provide actionable suggestions, tailored to a given user and context [3]. While such approaches are little investigated in this domain, we describe how we pursue that in the EU-funded project enCOMPASS (Grant Agreement no. 723059) [1].

2. APPROACH AND DESIGN OF THE ENCOMPASS END-USER APP

The enCOMPASS project [1] investigates how the integration of eco-feedback with gamification elements, personalized recommendations of energy saving actions and incentives adapted to different user types can stimulate changes in energy consumption behaviour. While the project addresses different building types, here we focus on the household scenario. The design of intuitive feedback on the consumed energy in the enCOMPASS end-user app takes into account that different categories of users may favour different types of visualizations. Firstly, metaphor-based visualizations are employed to relate abstract concepts to metaphors from everyday life. Secondly, for more data-oriented users, a data-driven bar chart allows detailed inspection of the consumption at different time scales. A battery metaphor is used to show the progress of energy consumption for a given month in relation to the same month of the previous year (historical comparison), and in relation to a (modifiable) savings goal suggested to the user (goal setting). The battery metaphor also communicates the notion of energy as a limited resource that should not be wasted. The impact of the achieved energy savings is also shown on three different dimensions: the monetary savings, the environmental impact (CO2 emissions) and the hedonic value (user's gamified achievements). The monetary impact is visualized with a piggy bank metaphor, the environmental one with a number of trees corresponding to saved CO2 emissions, and the hedonic one with jars filled with candies and badges collected through the obtained savings. The choice of these dimensions and the design of the visualizations have been informed by the goal-framing theory that identifies several motivational goals as drivers of pro-environmental behaviour [2]. To improve the users' capability of saving energy, which can increase the behavioural intention to act, energy saving tips are provided in a static (browsing) and in a personalised manner (recommendations). Personalised recommendations consider the size of the household, the observed

energy consumption, available appliances, in-home sensor data and presence patterns (temperature, weekday, hour). Based on this, the recommender prototype chooses which energy saving tips to present to whom and at which time. The recommendations are delivered as mobile notifications in the given time slots (in the first version chosen from predefined settings). To nudge users to read the recommendations, gamified elements are used (points and badges). To increase the likeliness of acting upon the recommended saving tips, personalized incentivization messages are given. Based on user responses to different motivational drivers, obtained in a sign-up questionnaire, the corresponding incentive message (money, environment, hedonic) is appended to the recommendation (e.g. "Decrease heating when leaving. This will help protect the environment.").

3. FORMATIVE EVALUATION OF A PROOF-OF-CONCEPT PROTOTYPE

Results of a formative evaluation of a proof-of-concept prototype app in an alpha test with 14 users suggest the suitability of the developed concept: most users found that the app would be useful in their daily life (10/14), and that it would motivate them to save energy (12/14). The different visualizations were also well received: all participants stated that it would motivate them to see how much money they could save (11 somewhat, 3 very motivated), and how much CO2 they could save (idem). They perceived as motivating to know the development of consumption information over time (detailed chart: 10 somewhat, 3 very motivated), the comparison against a historic baseline (detailed chart: 8 somewhat, 3 very motivated), and the comparison against a concrete goal (battery visualization: 8 somewhat, 2 very motivated). Energy saving tips were also perceived as motivating (9 somewhat, 3 very motivated), while responses to gamification elements were mixed: 6 participants felt motivated by points and badges (3 undecided, 5 negative), 8 by tangible rewards (1 undecided, 5 negative) and only 4 by the leaderboard (5 undecided, 5 negative). One reason for that could be the very short time of app usage in a test setting, which made it difficult to get a real sense of competition or achievement. Another limitation is that the personalized recommendations and adaptive incentives could not be tested at this stage, though their mock-ups were well received in previous workshops.

4. CONCLUSIONS AND FURTHER WORK

The evaluation of the proof-of-concept prototype suggests the suitability of the overall design, but must be taken with caution due to the mentioned limitations. The impact of the enCOMPASS app on users' energy consumption and antecedents of behavioural change will be assessed during 14-months of real-world usage in pilots in three different countries (D, CH, GR) which started in June 2018.

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