E-COmate: What's Your Non-consumption?

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Abstract. Most people lack awareness and hence understanding about how food-related behavior affects the environment. This commonly results in unsustainable food-related decision making, such as food waste. We propose E-COmate, an augmented bin that measures the weight of food waste through a USB postal scale, a bin and a Raspberry Pi with a Wi-Fi module, and give direct feedback to its users through a tablet by visualizing metaphorical units of the weighted food waste. We intend explore the use of E-COmate in redirecting behavior through transparency, visibility and social influence strategies like social comparison. In this paper, we present our concept, implementation, design rationale and plan of research which we expect to provide insights into the potential of eco-feedback integrated in smart home technology for food sustainability.

Keywords: Eco-feedback · Food sustainability · Social interaction

1 Introduction

The lack of awareness of everyday food behaviors goes hand in hand with a lack of understanding about its consequences for our environment [1]. Increasing awareness around food waste is one of the main approaches to reduce environmental impacts of food related behavior [1]. Roughly one-third of food produced for human consumption is lost or wasted globally, which accounts to about 1.3 billion tons per year [2]. A commonly used strategy to increase awareness of resource use and to encourage conservation is through eco-feedback [3]. The aim of eco-feedback is to increase awareness by automatically sensing peoples' activities and feeding related information back through computerized means, to foster positive attitudes towards sustainability [4] and hence the adoption of sustainable behaviors. It replaces hidden environmental information and behavior

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patterns with more accessible and understandable information [5]. To our knowledge, little attention has been paid on how to apply eco-feedback on reducing household food waste with the prospective to increase awareness and lower the impact of every day food-related decision-making on the environment. In this paper we present E-COmate, an eco-feedback system that measures (figure 1) and visualizes household food waste in metaphorical units and provide a comparison with the performance of other households (figure 2). E-COmate is based on our previous prototype described in [6], which was used for an initial pilot test of a week. The previous version was limited in visualization as it could only show wasted meals for a period of a week. With our design rationale and research aims we intend to explore the effects of social influence strategies on food-related decision-making and associated social aspects.

Fig. 1. The bin-scale system of E-COmate with wooden enclosure to protect the Raspberry Pi and to keep the scale and bin fixed. Led lamps indicate when the Raspberry Pi with its program has started (red), when the scale is connected to the Raspberry Pi (orange) and when the Raspberry Pi measured a stable weight and is uploading it to a server.

2 Background

Food technology in homes is expected to have a major impact on the sustainability of food consumption practices. Smart refrigerators, for example, are capable to record expiration dates, so that food can be closely monitored and prevented to get wasted [7]. Cooking appliances are being designed with embedded interactive games or technology to increase interests on the food waste problem [8,9] or to promote change towards alternative meals [10,11]. Although eco-feedback is generally used for other types of consumption such as energy or water use in households [12], its impacts on food waste and related behavior is rarely studied. With current concerns on food security and the global issue on food waste we propose to explore how eco-feedback can be useful for adopting sustainable food practices.

Visibility on Meaning. Throughout all food-related practices we use a crucial function of our brain; the ability to use stored information (what food we have at home) to imagine and predict possible future events such as what to buy or what to cook and eat [13]. Goal and future-oriented behavior and our ability to predict correctly is crucial in whether we will waste or not. When having a busy lifestyle, food practices receive less attention and behaviors resulting into food waste become more unconscious [14]. Eco-feedback could allow consumers to learn, 'incidentally' and without the requirement of conscious effort, what it means to waste food. For example, when we dispose food, unperceivable sources are disposed at the same time which we cannot see as it is beyond our immediate perception. Water and energy that was used for production are all lost when food is disposed. Next to natural resources we also waste physical energy, time and money. With our human ability to imagine non-perceivable or non-existent situations, eco-feedback could help our imagination by visualizing a future prediction: such as if current unsustainable behavior is continued (e.g. we would need 2 earths to produce food, considering one third is wasted) or present a 'what if' situation (e.g. if I didn't throw away this amount of food, I could have had x amount of free food). In sustainability research, information-based strategies were found to be effective at reducing overall energy usage in controlled experimental studies which indicates the potential of educational information technologies targeting conservation in households [15].

3 Design Probe and Rationale

E-COmate is an augmented bin that measures the weight of food waste and give direct feedback to its users through an Android application by visualizing the potential number of servings that has been wasted (See figure 1 and 2). The prototype consists of a laser-cut wooden enclosure with a USB postal scale, a bin and a Raspberry Pi with a Wi-Fi module. The application runs on a tablet computer to visualize the amount of wasted potential servings. With the visualization we aim at providing meaning of wasted food to increase awareness of hidden facts. Visualizations could be done through the number of bottled water, landfills or calories used for the production of the food that is wasted, the number of people that could have been fed for a day or how many earths we need if everyone would continue wasting the same. However, we chose to visualize the number of servings lost because it is directly linked to consumers own daily concerns, wasted meals equals potential free meals. Through real-time feedback embedded in their home environment, we provide a way for consumers to learn and reflect about their everyday behaviors on a daily basis.

Metaphors to Improve Understanding. In general, eco-feedback research use metaphors for visualization to enhance understanding of the information that is fed back to the user. Researchers have explored ways to inform consumption by using metaphorical units instead of volumetric units; such as everyday objects like the number of jugs and oil trucks for water usage instead of just the visualization of the number of gallons or liters [16]. In another recent example researchers used carbon weight to indicate environmental health visualized on a bathroom scale [12]. E-COmate visualizes the number of potential servings as a metaphorical unit converted from the weight of wasted food. We expect that the number of potential servings could be associated with monetary loss and hence another means for persuasion. Although studies on energy use have pointed out that financial incentives have short-lived effects and can be counterproductive [15], whether it also applies to food waste is unclear. Financial benefits from saving energy are often quite small compared to other household expenses like food [17].

Social Influence Strategies as a Means for Persuasion. To advance the impact of eco-feedback on food waste, we are interested in implementing social influence strategies in the design of the system and explore its effects on social aspects of food waste related behavior. We seem to compare ourselves to others to find out how we're doing when objective measures for self-evaluation are unavailable [18]. Hence, a common influence strategy in eco-feedback research is the use of social comparison as motivation for reducing consumption. Social approval and norm activation are principles that humans use to influence others and seem to be successful when facilitated through technology for supporting behavioral change towards more sustainable practices [19]. Consumers seem to be more motivated to save energy and water when they are able to compare consumption with others [20,21]. Including social aspects when studying food waste related behavior, is therefore considered critical.

3.1 Software and Hardware Design

E-COmate includes an off-the-shelf Dymo M5 USB postal scale which transmits its measurements via a USB connection to the Raspberry Pi. The Raspberry Pi handles the collection and saving of data into a server, as well as the communication with the scale. An eco-feedback manager reads the data from the server and controls the visualizations in the Android application which is programmed in JavaScript. All button presses in the application are saved in the server. All data in the server can be exported to csv or text files for analysis. Implementations are planned for 4 households in which each bin-scale system has his own id and its unique associated Android application with a similar id (see figure 3).

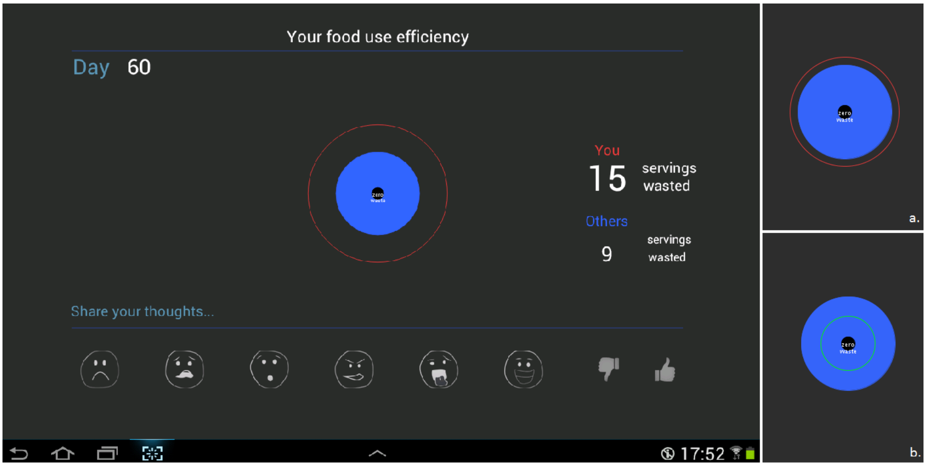

Fig. 2. The data from the bin-scale system is fed into an application for visualization of food waste on a tablet computer. This figure presents a display with social comparison with negative feedback relatively to *others*. The radius of this blue circle presents *others* and is kept constant for simplicity and consistency (*see a.*). When users waste less than *others*, "you" and the red circle changes to green and the circle then falls inside the blue circle (*see b.*)

3.2 Information Design

The display shows 2 types of information feedback (See figure 2). Numerical values are provided for the number of days and the amount of potential servings wasted by users since the start of usage. When the display includes social comparison, another number is presented for the amount of servings wasted by *others*. The numerical values are supported with a visualization based on the common visualization used for the *Earth overshoot day* concept; which signifies the gap between our demand for ecological resources and services, and how much the planet can provide [22]. Based on this idea, the display visualizes the relative difference between zero waste and participants' current waste and/or the amount others are wasting. The colors green and red are used for positive and negative feedback respectively in comparison with others. The display also includes buttons for users to interact and express feelings towards the feedback. We used six universal emotions *sadness*, *surprise*, *disgust*, *fear*, *anger* and *happiness* [23] and included a thumbs up and a thumbs down in case users do not want to express emotions.

3.3 Objective

Our main objective is to explore the effects of using eco-feedback applied to food waste. Particularly we are interested in how social comparison information can play a role in the motivation to adopt sustainable behaviors in daily food

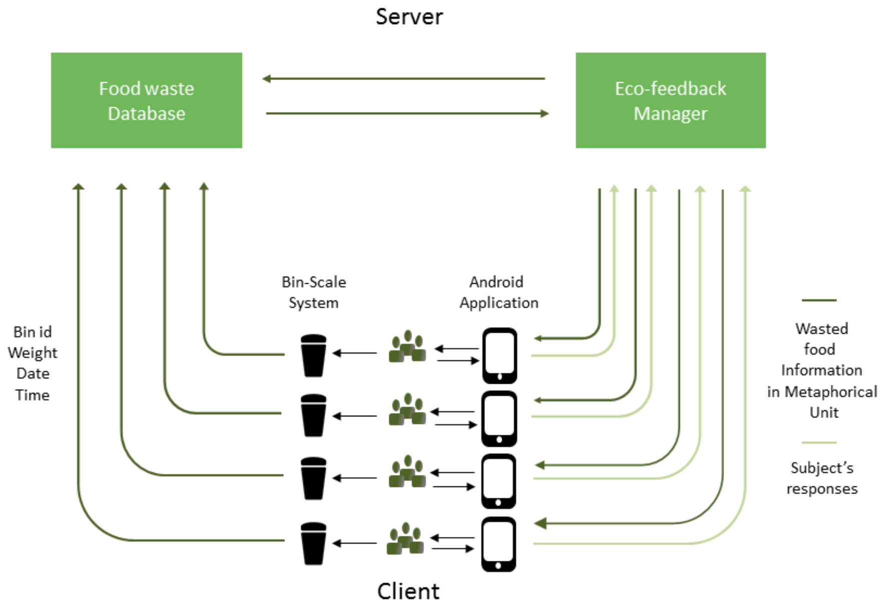

Fig. 3. Information flow of E-COmate for a study with 4 user groups

related practices. We include social aspects in our explorations as we consider it an important measure related to food practices. We investigate the following research questions:

1. How does eco-feedback affect food waste?
2. How does eco-feedback affect environmental attitude, social value orientation, memory and sustainable behavior in general?
3. How does eco-feedback with or without social comparison affect reflection and motivation?
4. How does eco-feedback with or without social comparison affect social group dynamics around food practices?
5. How should eco-feedback be designed to gain efficiency and be effective in reducing food waste?

4 Study Design

4.1 Participants

We recruited student houses that will use E-COmate for 1 month continuously including 7 days for the baseline measurement. Each house uses one E-COmate. Participants are recruited based on the following requirements; (1) they have to do groceries themselves which requires responsibility and (2) they have to eat or

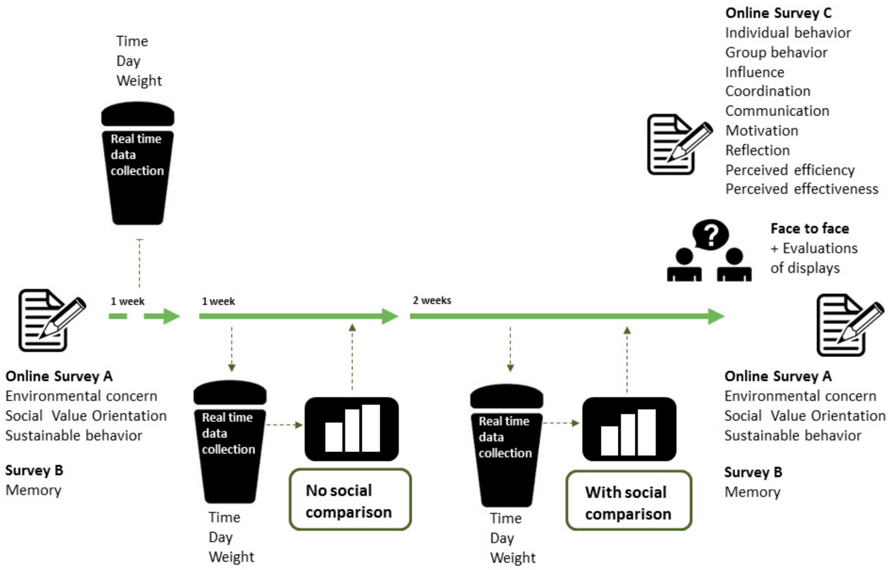

Fig. 4. Experimental design

cook at home at least three times a week which would mean that there will be ingredients stored in homes hence with a possibility of wastage.

4.2 Experimental Design

The study will start with a baseline measurement of 7 days without any interventions in terms of eco-feedback. This baseline aims at getting users used to separating food waste and using the scale-bin system. All participants will then be presented with 2 types of displays alternately. In the first week after the baseline, the application displays eco-feedback without social comparison (condition 1) followed by eco-feedback with social comparison (condition 2) for another 2 weeks. For research purposes we simulate the food waste information of *others* by randomly taking 40 % to 110 % of users actual waste. This means that users will mostly get negative feedback. This way we can look into the effects of receiving negative feedback when behavior is compared to other people or national standards. Although any food waste should be prevented anytime, social norms might have some influence. Our rationale behind this is to control for consistency among all participants in feedback provided independent from the differences in waste. Dependent measures will be gathered through the bin, online surveys and an interview (See figure 4 for an overview and time line of the experimental design).

4.3 Measuring the Effects of Eco-feedback

Two online surveys will be conducted in the beginning and at the end of the study to explore effects of eco-feedback. One survey contains three standardized questionnaires to measure ecological concern, social value orientation and general sustainable behavior. The second online survey aims at measuring participant's performance on memory.

Environmental Concern. The level in which people are concerned about their environment can be measured, among others, by the Ecological Motives Scale [24]. This 12-item scale provides a measure of someones concern about environmental problems because of the consequences that result from harming nature. Participants are asked to rate items from 1 (not important) to 7 (supreme importance) in response to the following question:

"I am concerned about environmental problems because of the consequences for ______".

The scale measures three categories of concern about environmental problems caused by human behaviors: Egoistic, Altruistic, and Biospheric. Egoistic items are: *me*, *my future*, *my lifestyle*, and *my health*. Altruistic items are: *all people*, *children*, *my children*, and *people in my country*. Biospheric items are: *plants*, *animals*, *marine life*, and *birds*. Subscales are scored by averaging the scores from the items within the subscales. Higher scores represent higher concern with a given subscale. This measure could give us insights in how people respond to using our prototype depending on their level of concern.

Social Value Orientation. Social value orientation (SVO) is a person's preference about how to allocate resources between the self and another person [25]. The measure has six primary items (See figure 5 for an example item), used to group people who seek to maximize their gains into being pro-self or competitive and people who are also concerned with other's gains and losses into being pro-social or altruistic. All of the items have the same general form, each is a resource allocation choice over a well defined continuum of joint payoffs. We believe this measure could be relevant and possibly related to food-related behavior. Food behavior is socially and culturally integrated and preventing food waste comes together with social responsibility, for future generations as well. Hence, this measure could give us insights in how people respond to using our prototype depending on their social value orientation. Not wasting food could, however, also be caused by having a self-centered reason such as saving money.

Prospective Memory. The bad performance of memory of past information has been indicated as one of the main causes in qualitative food waste studies [14]; e.g. forgetting what is available at home or the days how long an item is good for due to busy and unpredictable lifestyles. A subcategory of memory,

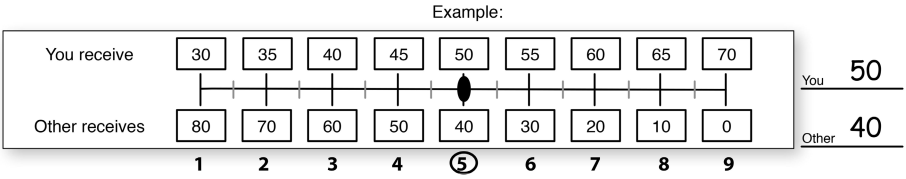

Fig. 5. An example of a primary SVO items

prospective memory, which is the memory of future events, is found to be crucially involved in our ability to imagine non-existent events and simulate future happenings [13,26]. This type of memory is obviously also related to food waste behavior; e.g. future plans on what to do with the available items at home. Both types of memory, about the past and the future is, therefore, another kind of human aspect that should be taken into account when exploring technological interventions for food waste prevention. In our study we ask participants to describe two past events and two future events related to food behavior with as much detail as possible (e.g. time, place, people etc.); a dinner from the past week, a planned dinner in the next few days, food items they had available last week for at least two days and food items they are planning on purchasing in the next few days. Answers can be scored for detail considering the number of words, number of distinguishable aspects, and the specificity of time and space.

General Ecological Behavior. Although, holding a certain attitude might affect behavior, this is not always the case. Therefore, in addition to levels of concern, attitude, values and intention triggered through memory, we should look at actual behavior. We use a questionnaire from Kaiser [27] which includes 50 items addressing a wide range of conservation behaviors. Respondents are asked to indicate whether or not they have ever engaged in a particular behavior. Topics include energy conservation, mobility and transportation, waste avoidance, consumerism, recycling, vicarious social behaviors towards conservation and in addition, we included 6 items related to food waste (See table 1). People who are raised in a sustainable environment are more likely to adopt a variety of sustainable behaviors. When one sustainable behavior is adopted, people might also be more likely in adopting other sustainable behaviors to stay consistent. Here, we build on the theory of cognitive dissonance [28], the feeling of discomfort when simultaneously holding two or more conflicting cognitions: ideas, beliefs, values or emotional reactions. In this case, behavior could lead to an adaptation of attitude and other behaviors when using sustainable technology.

4.4 The Potential of Applying Social Comparison

A third online survey will be conducted at the end to explore the effects of eco-feedback with social comparison or the lack thereof and users' preferences. Here, we are interested in individual and group related behavior, which is further

Table 1. 56 conservation behaviors grouped into seven performance domains

Table General Ecological Behavior
Energy conservation
1. I own energy efficient household devices
2. I wait until I have a full load before doing laundry
3. I wash dirty clothes without prewashing
4. In hotels, I have the towels changed daily
5. I use a clothes dryer
6. I bought solar panels to produce energy
7. I use renewable energy sources
8. In the winter, I keep the heat on so that I do not have to wear a sweater
9. In the winter, I leave the windows open for long periods of time to let in fresh air
10. In winter, I turn down the heat when I leave my apartment for more than 4 h
11. I prefer to shower rather than to take a bath
Mobility and transportation
12. I drive my car in or into the city
13. I drive on freeways at speeds under 62.5 mph
14. I keep the engine running while waiting in front of a railroad crossing or in a traffic jam
15. At red traffic lights, I keep the engine running
16. I drive to where I want to start my hikes
17. I refrain from owning a car
18. I am a member of a carpool
19. I drive in such a way as to keep my fuel consumption as low as possible
20. I own a fuel-efficient automobile (less than 7 liters per 100 km)
21. For longer journeys (more than 6 h), I take an airplane
22. In nearby areas (around 30 km), I use public transportation or ride a bike
23. I ride a bicycle or take public transportation to work or school
Waste avoidance
24. I buy milk in returnable bottles
25. If I am offered a plastic bag in a store, I take it
26. I reuse my shopping bags
27. I buy beverages in cans
28. I buy products in refillable packages
51. I tend to overbuy food that get wasted
52. Past food date is a common reason for throwing out food
53. Forgetting leftovers is a common reason for throwing out food
Consumerism
29. I use fabric softener with my laundry
30. I use an oven cleansing spray to clean my oven
31. I kill insects with a chemical insecticide
32. I use a chemical air freshener in my bathroom
33. I buy convenience food
34. I buy seasonal products
35. I buy bleaches and colored toilet paper
36. I buy meat and products with eco-labels
37. I buy domestically grown wooden furniture
54. I am a vegetarian
55. Sometimes I don't mind eating vegetarian
56. I want to reduce my meat consumption
Recycling
38. I collect and recycle used paper
39. I bring empty bottles to a recycling bin
40. I put dead batteries in the garbage
41. After meals, I dispose of leftovers in the toilet
Vicarious, social behaviors towards conservation
42. After a picnic, I leave the place clean as it was originally
43. I am a member of an environmental organization
44. I read about environmental issues
45. I contribute financially to environmental organizations
46. I talk with friends about problems related to the environment
47. I have pointed out unecological behavior to someone
48. I boycott companies with an unecological background
49. I have already looked into pros and cons of having a private source of solar power
50. I requested an estimate on having solar power installed

specified in planning, purchasing, preparation, and dealing with leftovers. Other items focus on how much the system supports reflection, affect motivation to change behavior and how much the system affect social interaction in terms of influence, coordination and communication. Answer options ranged from *very much* to *not at all*, with item's score contribution from 5 to 1, respectively. Semi-structured interviews at the end of the study are based on the same questionnaire items, but aiming for more in-depth discussions on *how* the system had affected their behaviors. Here, we explore perceived efficiency and effectiveness of E-COmate and gather evaluations of alternative displays and design dimensions.

4.5 Procedures

We provide the following task descriptions to participants: (1) related to the use of the bin, they will be asked to only throw away food waste that was once edible but now turned bad or currently doubtful (e.g. past due date). A list will be provided with items that are allowed (e.g. potato skins, vegetable peels and greens, bread crusts, over baked or overcooked food, plate scraps etc.) and items that are *not* allowed in E-COmate (e.g. bones, tea bags, coffee grounds, egg shells, banana peels etc.). Instructions will be provided on the procedures of using the bin and how to read and use the display. To dispose food, users have to wait until the green light goes on *and* off again before disposing something else *or* before emptying it as it needs 8 seconds to stabilize and send data to the server. Users also have to turn off the scale and wait until the orange light goes off before emptying the bin. Instructions also applies for when the system freezes; (2) related to the Android application, whenever participants see the eco-feedback on the tablet they can interact with it by indicating current emotions or whether they like it or not; (3) for data gathering other than the food waste weight, participants fill in two online survey before and three after the study. All surveys are send by email and an interview takes place at the end of the study; finally (4), comments or pictures taken by participants throughout the study can be send and shared within a WhatsApp chat group of the users belonging to one house. This chat group can also be used for any question related to the study.

5 Discussion

With E-COmate we aim at exploring the effect of using social comparison in eco-feedback on food-related behavior in individuals as well as groups of users in terms of influence, coordination and communication among users. We are further interested in how it supports reflection and affect motivation to change behavior. Overall, we are interested in exploring the effects of E-COmate on memory, attitude and sustainable behavior in general and we aim at discovering hidden temporal patterns in the data collected through E-COmate: when are people more likely to waste (e.g. in the evening or before shopping, etc.)? This would help determine the causes of food waste, currently under explored.

Quantitative and qualitative findings on these aforementioned behavioral and cognitive aspects could help in designing a smart home system that is likely to be effective for reducing food waste in households. Targeting these goals we face the following challenges: the raw data from the scale-bin system include noise such as fluctuations in the weight that is measured when nothing should change and 0 measurements when the system is turned off (e.g. when frozen or internet connection is lost). From this raw data, useful data is filtered out and converted into something understandable, meaningful and realistic for visualizations to be useful. The definition of noise, however, is based on our own assumptions (e.g. a bin will only be emptied when it has a significant content so a decrement of weight that is less than a certain value can be considered noise and an increment that is less than a certain value might be other than actual food waste such as touching the bin). Another challenge is whether an in the wild approach can reliably capture food and/or waste data at the consumer level for a period of a month. The accuracy of the electronics inside the scale can reduce by time and remotely monitoring users could limit data. Furthermore, food waste monitoring have implications on privacy matters. It is another source of peoples private behavior they might likely not want to share. Food waste information could be a target for taxes for example. This leads to the question on why people would want to use it. We, however, believe that E-COmate could lead to being more economical and be used for educational purposes and hence to increase awareness.

5.1 Future Work

Future work involves the deployment of E-COmate in multiple households for a period of a month of which findings will be used as a source of inspiration for next prototypes. In these follow up prototypes we could explore the use of different metaphors and distinguish between food types (e.g. fruits and vegetables, meat and fish, dairy, and grains). Meat for example requires much more resources, so eating as well as wasting it has much more impact on our environment. We could explore how this information can be presented and how it effects consumption or wastage. We could also look into the effects of receiving positive feedback when behavior is compared to other people or national standards (e.g. by randomly taking 90 % to 160 % of users actual waste).

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References

1. Moomaw, W., Griffin, T., Kurczak, K., Lomax, J.: The critical role of global food consumption patterns in achieving sustainable food systems and food for all. Tech Report, United Nations Environment Programme (2012)

2. Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., Meybeck, A.: Global food losses and food waste. Tech Report, Food and Agriculture Organization of the United Nations (2011)
3. Froehlich, J., Findlater, L., and Landay, J.: The design of eco-feedback technology. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1999–2008. ACM, New York (2010)
4. Pierce, J., Odom, W., and Blevis, E.: Energy aware dwelling: A critical survey of interaction design for eco-visualizations. In: Proceedings of the 20th Australasian Conference on Computer-Human Interaction, pp. 1–8. ACM, New York (2008)
5. Holmes, T.: Eco-visualization: Combining art and technology to reduce energy consumption. In: Proceedings of the 6th ACM SIGCHI Conference on Creativity & Cognition, pp. 153–162. ACM, New York (2007)
6. Lim, V., Jense, A., Janmaat, J., Funk, M.: Eco-feedback for non-consumption. In: Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication, pp. 99–102. ACM, New York (2014)
7. Rouillard, J.: The Pervasive Fridge; A smart computer system against uneaten food loss. In: The Seventh International Conference on Systems, pp. 135–140. Saint-Gilles, Runion (2012)
8. Comber, R., Hoonhout, J., van Halteren, A., Moynihan, P., Olivier, P.: Food practices as situated action: exploring and designing for everyday food practices with households. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2457–2466. ACM, New York (2013)
9. Lepe Salazar, F., Yamabe, T., Alexandrova, T., Liu, Y., Nakajima, T.: Family interaction for responsible natural resource consumption. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2105–2110. ACM, New York (2012)
10. Clear, A. K., Hazas, M., Morley, J., Friday, A., Bates, O.: Domestic food and sustainable design: a study of university student cooking and its impacts. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2447–2456. ACM, New York (2013)
11. Kadomura, A., Li, C-Y., Tsukada, K., Chu, H-H., Siio, I.: Persuasive technology to improve eating behavior using a sensor-embedded fork. In: Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing, pp. 319–329. ACM, New York (2014)
12. Kuo, P-Y., Horm, M.S.: Energy diet: energy feedback on a bathroom scale. In: Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing, pp. 435–446. ACM, New York (2014)
13. Schacter, D.L., Addis, D.R., Buckner, R.L.: Remembering the past to imagine the future: the prospective brain. Nature Reviews Neuroscience **8**, 657–661 (2007)
14. Ganglbauer, E., Fitzpatrick, G., Molzer, G.: Creating visibility: understanding the design space for food waste. In: Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia, pp. 0–9. ACM, New York (2012)
15. Delmas, M., Fischlein, M., Asensio, O.: Information Strategies and Energy Conservation Behavior: A Meta-analysis of Experimental Studies from 1975–2011. Working Paper, Institute of the Environment and Sustainability, UCLA, Los Angeles (2013)
16. Froehlich, J., Patel, S., Landay, J., Findlater, L., Ostergren, M., Ramanathan, S., Peterson, J., Wragg, I., Larson, E., Fu, F., Bai, M.: The design and evaluation of prototype eco-feedback displays for fixture-level water usage data. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2367–2376. ACM, New York (2012)

17. Wolak, F.: Do Residential Customers Respond to Hourly Prices? Evidence From A Dynamic Pricing Experiment. American Economic Review **101**(3), 83–87 (2011)
18. Festinger, L.: A theory of social comparison processes. Human Relations **7**(2), 117–140 (1954)
19. Ham, J.R.C. & Midden, C.J.H. (2014).: A persuasive robot to stimulate energy conservation: the influence of positive and negative social feedback and task similarity on energy consumption behavior. International Journal of Social Robotics 6(2), 163–171 (2014)
20. Foster, D., Lawson, S., Blythe, M., and Cairns, P.: Wattsup?: Motivating reductions in domestic energy consumption using social networks. In: Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries, pp. 178–187. ACM, New York (2010)
21. Odom, W., Pierce, J., and Roedl, D.: Social incentive & eco-visualization displays: toward persuading greater change in dormitory communities. In: Workshop Proceedings of Public and Situated Displays to Support Communities. ACM, New York (2008)
22. Global Foodprint Network; Advancing the Science of Sustainability. http://www.footprintnetwork.org
23. Black, M.J., Yacoob, Y.: Recognizing facial expressions in image sequences using local parameterized models of image motion. Int. Journal of Computer Vision **25**(1), 23–48 (1997)
24. Schultz, P.W.: The structure of environmental concern: Concern for the self, other people, and the biosphere. Journal of Environmental Psychology **21**, 327–339 (2001)
25. Murphy, R.O., Ackermann, K.A., Handgraaf, M.J.J.: Measuring Social Value Orientation. Judgment and Decision Making **6**(8), 771–781 (2011)
26. Suddendorf, T., Busby, J.: Making decisions with the future in mind: Developmental and comparative identification of mental time travel. Learning and Motivation **36**, 110–125 (2005)
27. Kaiser, F.G., Wilson, M.: Goal-directed conservation behavior: The specific composition of a general performance. Personality and Individual Differences **36**, 1531–1544 (2013)
28. Festinger, L.: A Theory of Cognitive Dissonance. Stanford University Press, California (1957)