"Less is more: Preventing Household Food Waste through Mobile Applications"

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0. Background

Across the global food-supply chain approximately 1.3 billion tons of food are lost or wasted each year (Gustavsson et al., 2011). This is equivalent to one third of all edible food being disposed of across all stages from production to consumption (Gustavsson et al., 2011). In developing countries, the majority of food loss occurs on the production side due to a lack of efficient agricultural technology and limited infrastructure (Parfitt et al., 2010). In developed countries, on the other hand, the majority of food is wasted at the consumer level (Gustavsson et al., 2011). A 2011 report by the European Commission on the annual food wastage across the EU27 countries suggests that the share of household food waste is as high as 42% (Monier et al., 2011). This amounts to an average of 76kg of yearly per capita household food waste in the EU27 countries (Monier et al., 2011). The enormous wastage of food has significant implications, which can be analyzed along three dimensions: environmental, social and economic.

The impact of food waste on the environment is twofold (Thyberg & Tonjes 2016). Firstly, the overproduction of food poses an additional strain on scarce resources. The production of food requires resources such as land and water and is also connected to the emission of greenhouse gases. For one, agriculture is the largest source of water use world-wide and as demand for food increases, the danger of water scarcity increases as well (Lundqvist et al., 2008). Simultaneously, up to 15% of all greenhouse gases are currently emitted due to food production (Godfray & Garnett, 2014). Taken together with the trend of global population rise and predictions that assume the population to reach 9.7 billion by 2050 (UN, 2019), the impact of the overproduction of food can be expected to intensify. The disposal of food waste in landfills additionally leads to greenhouse gas emissions and thereby promotes climate change. As food degrades in landfills, it releases both methane and carbon dioxide (Levis & Barlaz, 2011). More so than carbon dioxide, methane is a key contributor to the warming of the planet as its impact on the climate over a period of 100 years is 34 times higher than carbon dioxide (IPCC, 2013). According to the US Environmental Protection Agency, only 25% of the methane from landfills is

captured and transformed into energy, whereas the rest is freely emitted into the atmosphere (USEPA, 2011).

The social implications of food waste concern the problem of food insecurity. While one third of all edible food is lost or wasted, globally over 820 million people still do not have secure access to food (FAO, 2019). Food insecurity reaches the entire globe, affecting both citizens in both developing and developed countries, although at a different degree (FAO, 2019). In some regions of the African continent up to 22.8% of the population is undernourished and up to 8% of people in North America and Europe do not have sufficient access to food (FAO, 2019). Under these circumstances, the wastage of food is a waste of resources, which could be invested to alleviate food insecurity elsewhere (Thyberg & Tonjes, 2016). At the same time, the production of food that is not consumed puts an additional strain on the global food supply chain and exacerbates the difficulty of providing for a growing population, while possibly increasing inequalities (Thyberg & Tonjes, 2016).

Finally, the economic dimension of the issue relates to food waste as a loss of economic value. It brings all the other dimensions together in that it quantifies the impact on the environment, on society in general, and on the consumer as an individual. The FAO estimates the cumulative costs of all food waste to be around USD 2.7 trillion per year (FAO, 2014). This includes around USD 1 trillion of economic costs, USD 700 billion of environmental costs and USD 900 billion of social costs (FAO, 2014). However, the FAO notes that due to calculation methods these numbers are only indicative and do not capture the full economic impact of food waste (FAO, 2014).

Various drivers contribute to the continuous wastage of food. As our further analysis focuses on urban areas in developed countries, we shall sketch an overview of the main drivers specific to these areas. With an ever-steady increase in urbanization, more citizens in developed countries live in cities than in rural areas. In 2018 in Northern America 82% and in Europe 74% of the population lived in urban areas (UN, 2019). Most agricultural processes, however, occur on farms in more rural areas (Thyberg & Tonjes,

2016). This physical distance and disconnect with the location of food production has led to a psychological disconnect with the sources of food and an increased lack of understanding of the labour and other resources involved (Parfitt et al., 2010; Thyberg & Tonjes, 2016). Additionally, with an increase in income, dietary patterns have changed to include more products with a short life span such as dairy, eggs or meat and less starchy products (Bennet, 1941; Lundqvist et al., 2008). The consumption of food with shorter life spans is further linked to a higher amount of food waste generation (Lundqvist et al., 2008). The disconnect with food sources taken together with an increase in the consumption of non-durable food products, positions cities as areas which are considerably vulnerable to an excessive wastage of food products.

One solution that has been put forward for urban areas is the use of ICT technologies as tools to minimize food waste (Ciaghi & Villafiorita, 2016; Harvey at al., 2019; Farr-Wharton et al., 2014). This essay therefore critically evaluates existing mobile applications and provides a final more comprehensive suggestion of a mobile app that can help urban environments to become more sustainable food systems.

1. Introduction

In Europe, the majority of food waste occurs at the household level (Parfitt et al., 2010). There are significant challenges to solving the issue household food waste, given that it is spread across many actors and often involves food that close to its expiration date (Ciaghi & Villafiorita, 2016). Information and Communications Technologies (ICTs), such as mobile applications, have great potential to reduce household food waste in urban areas given that they can be easily made available to a large proportion of consumers (Ciaghi & Villafiorita, 2016; Farr-Wharton et al, 2014).

In this essay, we analyse household food waste using Installation Theory (Lahlou, 2016) and recommend ways in which ICTs can help scaffold consumer behaviour to reduce waste. The term “Food waste” refers to “food appropriate for human consumption being discarded or left to spoil at a consumer level - regardless of the cause” (HLPE 2014, p. 22). It is distinct from food loss, which in the literature tends to refer to losses earlier in the food supply chain (Parfitt et al., 2010). The majority of consumer food waste is generated within the household as opposed to away from home (Principato, 2018), which is why we focus exclusively on household food waste. Specifically, we consider food waste generated within urban households of young consumers living either alone or in a shared flat. Young adults aged between 18 and 34 tend to waste more food than older demographics (Secondi, Principato, & Laureti, 2015) and are also more likely to use ICTs (Kubiatko, 2013), making them the ideal demographic for our analysis. Similarly, urban areas are not only responsible for producing more food waste (Secondi et al., 2015) but they offer networks and collaborative opportunities for the sharing of food amongst its members (Davies, & Evans 2019). Considering that more than half of the world's population currently lives in cities (UN 2019), interventions and solutions in cities are key to creating more sustainable food systems.

The structure of the essay is as follows: In section two, we first discuss the use of Installation theory to analyze food waste and then segregate household food waste into three distinct stages, each of which will be analyzed within section four. In section five,

we distill of our insights into a single ideal mobile application to tackle household food waste and will discuss its limitations. Section six offers a brief conclusion and a discussion of the limitations of this approach.

2. Theoretical framework for analysis: The Installation Theory

Two main theoretical approaches have been previously used to understand the reasons behind household food waste (Schanes, Dobernig, & Gözet, 2018). Psychology-oriented approaches have focused on identifying the cognitive and interpersonal factors that lead consumers to waste food (Steg, & Vlek, 2009). The theory of planned behaviour (Ajzen, 1991) for example, has been used to explain food waste in terms of individual motivations and intentions (Graham-Rowe et. al, 2015). Sociological approaches have instead focused on the influence of societal and external factors (Schanes et al., 2018). Social practice theory, for example, can be used to explain food waste as the product of household practices influenced by a wider economic and social context (Southerton, & Yates, 2014).

While psychology-oriented theories offer insights into individual psychological mechanisms that account for food-waste, they fail to explain why people's intentions to prevent food waste often fail to manifest behaviorally (Schanes et al., 2018). On the other hand, social practice theory allows for a clearer understanding of this intention-behaviour gap but lacks a deeper explanation regarding the individual's interaction with environmental cues (Schanes et al., 2018). Schanes and colleagues (2018) note that a better comprehension of food waste behaviour stems from the integration of these two complementary views. Installation Theory as an analytical framework allows us to incorporate both perspectives as it explains behaviour as resulting from environmental, social and individual factors (Lahlou, 2016).

Installation theory takes as its unit of analysis the *installation:* A "specific, local, societal setting, where humans are expected to behave in a predictable way" (Lahlou, 2016, p.15). Each installation is seen as composed of three layers: embodied competences (in the

individual), material affordances (in the environment), and social regulations (within society). These three layers act together (often in a redundant manner) to scaffold and make human behaviour predictable within specific circumstances (Lahlou, 2016). The essence of any given installation is the activity it supports and which (in principle) is aligned with the goals of its users (Lahlou 2016, p. 16).

We use Installation Theory as an analytical framework for two reasons: First, as discussed, it allows us to bridge a gap within the theoretical literature, offering a more comprehensive understanding of food waste behaviour. Secondly, Installation theory is devised as a means to produce behavioural change in real-world situations and is optimal for the identification of real-world practical solutions (Lahlou, 2016). In this essay, we hold that ICTs, and mobile applications in particular, can be seen as objects that alter the installation they are brought into. While leaving the physical layer of installations unchanged, we see mobile applications as scaffolding individuals behaviour by extending and improving embodied competences. For example, a simple shopping list acts as an artificial extension of the individual's memory (cf. Farr-Wharton et al., 2014). Additionally, social norms are also active in digital environments, particularly when users interact with other users online (Major, 2000), suggesting that the social layer of installations can potentially be altered or extend by mobile applications which are used within the installation.

2.1. The three stages of food waste

Consumers interact with food items in various contexts and with various goals. Analysis is thus facilitated by segmenting household food waste into distinct stages. Several such taxonomies have already been proposed, each outlining a path from the point of purchase, proceeding through consumption and ending in the disposition of uneaten food (Block et al., 2016; Principato, 2018; Schanes et al., 2018). Differences in the models relate to whether certain specific activities, such as meal planning, meal preparation or storage are classified as distinct phases or not.

We choose to build on the commonalities of these three models and adopt a simple three-stage sequence, composed of “Acquisition”, “Consumption” and “Disposition” for our own analysis. To facilitate analysis under installation theory, we conceive of each stage as being defined by a central activity which *tends* to occur in a specific installation (although exceptions exist). “Acquisition” is thus defined by the activity of selecting and purchasing food for subsequent consumption, and the typical associated installation is the supermarket. “Consumption” contains the activity of preparing and eating food which one already owns. Lastly, we define “Disposition” to include activities in which consumers dispose of food they own, which can include throwing it in the garbage, recycling it or giving it to someone else.

We do accept that planning and meal preparation are hugely important, but simply treat these activities as part of Acquisition and Consumption respectively, because they are directly instrumental to the overarching activity. Similarly, storage will be discussed throughout the entire sequence as an activity important for food waste at each stage.

Stage	**Central Activity**	**Relevant Installation**
Acquisition	Purchasing food	Supermarket
Consumption	Preparing and eating food	Kitchen
Disposition	Disposing of uneaten food	Kitchen

Table 1: The three stages of food waste used in our analysis. Each is associated with a central activity which is scaffolded by an Installation in our analysis.

3. Problem Analysis

3.1. Acquisition

Although we acknowledge that acquisition can occur in different settings (e.g. online, markets, restaurants etc.), we analyze the physical supermarket as the main installation for this phase. Compared to other shopping locations, large supermarket chains are the biggest drivers of food waste behaviour in consumers (Farr-Wharton et al., 2014). At this stage, food waste typically results from the over-purchasing of unneeded products, which are not consumed, and are consequently disposed of (Mallinson et. al, 2016). Impulse buying, defined as a purchase decision made in-store with no explicit recognition of a need for such a purchase prior to entry in the store (Kollat, & Willet, 1967), is accountable for nearly 60% of overall purchases and leads to over-purchasing (Mattila, & Wirtz, 2008). Given that impulse buying is consciously perceived by consumers as an unnecessary use of economic, mental and physical resources (Stern, 1962), it is cognitive biases and environmental cues, rather than consumer intentions, that best explain this phenomenon. The supermarket is thus analyzed as the installation enabling cognitive biases that lead to over-acquisition, and ultimately food waste.

3.1.1 Embodied Competences

Over-acquisition of products in the supermarket has been associated with poor planning skills as well as memory deficits in consumers (Block et. al, 2016). Consumers are affected by the planning fallacy (Kahneman, & Tversky, 1977), defined as the underestimation of how much time they will need to complete a future task. Regarding food acquisition, consumers may underestimate the time needed to prepare and eat any given meal, leading them to purchase more food than they will be able to cook and consume before it expires (Block et al., 2016).

In a supermarket, shoppers are also susceptible to the present bias (Block et al., 2016), which refers to consumers' inclination to focus more strongly on pay-offs in the present than on trade-offs that may occur in the future (O'Donoghue & Rabin, 1999). In practice, consumers may prefer to make use of in-store promotions and select for variety, rather than make their purchasing choices subservient to their planned consumption. On top of this, consumers may systematically underestimate the occurrence of unpredictable events and as of yet unplanned commitments, resulting in an overestimation of how many meals they will eat at home (Block et. al, 2016). Lastly, Given that many consumers do not make use of a shopping list while in the supermarket (Neff, Spiker, & Truant, 2015), the inability to recall one's kitchen inventory typically leads to buying pre-owned and unnecessary items that go to waste (Graham-Rowe et al., 2014).

3.1.2 Physical Affordances

Marketers have become increasingly aware of consumers' susceptibility to impulse buying and have been designing physical stores with the aim of eliciting these consumption biases through the infrastructure's physical properties (Lee, 2018). Firstly, the overall architecture and layout of supermarkets typically increase the amount of time that is spent shopping there compared to other stores, such as smaller markets. This has been attributed to greater over-acquisition and food waste (Abratt, & Goodey, 1990). Studies have also shown that eye-level shelves (Abratt, & Goodey, 1990), in-store signage (Woodside, & Waddle, 1975) and promotions (Wilkinson, 1982) all increase the amount of sales, by appealing to consumers through attractive visual cues (Abratt, & Goodey, 1990). Supermarkets also increase overconsumption of food by displaying a wide variety of similar products (e.g. different flavours). This leads to over acquisition by eliciting the diversification bias: consumers are attracted to buying products in bulk that contain variation, as they believe that in the future they will want different flavour choices, for example (Read, & Loewenstein, 1995). This, however, often leads to the partial consumption of goods, as buyers are more likely to consume their usual preferences, while disposing of disliked and unneeded options (Block et al., 2016).

3.1.3 Social Regulation

Social factors also influence purchases in the supermarket. A recent study demonstrated that the amount of healthy vs. unhealthy food purchased by shoppers was proportional to the amount of healthy and unhealthy products purchased by a confederate, showing how people's purchasing choices partly result from social monitoring (Bevelander, et. al, 2011). Further, it has been suggested that the recent rise of social media and online conversations about food and health may play a role in determining consumers' shopping preferences. A recent study has shown that purchasing of healthier foods has greatly risen thanks to brand advertisements and campaigns promoted on social media platforms (Samoggia et. al, 2019). This may lead consumers to over-purchase healthy food, which, however, will not be consumed (Block et al., 2016).

3.1.4 ICT Solutions

Based on our analysis, an effective way to reduce food waste resulting from over-purchasing at the acquisition stage is to counteract consumers' cognitive biases and memory deficits. Household inventory applications such as *No Waste* and *Plus Fridge Pal* can help consumers keep track of needed and unneeded items when shopping at the supermarket. Furthermore, these applications offer consumers a summary of their previous shopping and consumption experiences, displaying the items that have been previously bought and gone to waste, reducing the incidence of the present bias and planning fallacy, as well as the diversification bias. Planning behaviour and quantity of food purchased can also be facilitated through portion-ready food delivery services, such as *Hello Fresh.* This allows consumers to choose from a variety of different recipes online. Ingredients for these are then delivered to their homes in the quantities that are exactly needed to cook. Not only this allows consumers to enjoy a variety of products they enjoy,

it also allows individuals to shop from their homes, reducing their susceptibility to over-purchase within the supermarket installation.

3.2 Consumption

During this stage, consumers make decisions regarding preferred food to eat, which ingredients to use, and the quantity to cook, serve and eat (Block et al., 2016). We will understand food waste in this stage as “food thrown away that was, at some point prior to disposal, edible and could have been eaten if it had been better portioned, managed, stored and/or prepared” (Secondi et al., 2015, p.3). An important part of this stage is whether consumers choose to reuse leftovers after a meal, as doing so may be one of the most effective ways of reducing household food waste (Secondi et al., 2015). We focus on the kitchen as the general installation for preparing and eating a meal, while acknowledging that there is a great variety between households. Some flat shares, for example, may have a common dining table, while others do not.

3.2.1 Embodied competences

Embodied interpretive systems such as experience, knowledge and skills drive consumers’ behaviour in the kitchen. Memory of items available in storage affects the decision on what to eat or what ingredients to use when cooking. People forget they have bought ingredients in the past and let them expire (Block et al., 2016). Furthermore, people lack the knowledge on how to use sensory skills (taste and smell) to interpret freshness of food correctly (Principato, 2018), increasing fear of foodborne illness and consequently waste (Secondi et al., 2015). Leftover food composed of fish, meat, or dairy products are usually thrown away more often (Ghinea et al., 2018). Lack of knowledge in distinguishing labels on food products between “best before” and “expiration” dates contribute to this. Eating food after the date displayed on the packaging is considered dangerous, even though in many cases there is no risk, it encourages people to dispose

of edible food too early (White et al., 2016; Mondéjar-Jiménez et al., 2016). Some labels such as “sell by” are created to suggest the date by which the store should stop offering the product. “Best by”, “best before” and “use by” are estimates of dates of when the product will maintain its highest quality (Terpstra et al., 2005). This does not mean that the product is no longer safe to eat (Block et al., 2016). Similarly, wrongful perceptions of health risks associated with eating leftovers influence whether they are thrown away after a meal (Farr-Wharton et al., 2014; Visschers, Wickli, & Siegrist 2016). Simple preference for novel and freshly prepared meals also plays a role (Cappellini, 2009).

Crucially, people lack the knowledge on how to use sensory skills (taste and smell) to interpret freshness of food correctly (Principato, 2018) and the fear of foodborne illness increases waste (Secondi et al., 2015). Leftover food composed of fish, meat, or dairy products are usually thrown away more often (Ghinea et al., 2018).

It should also be noted that unappealing leftover food can be transformed and seen as “fresh” again by a process of rediscovery, reevaluation and preparation in the kitchen. An example is when leftover chicken bones are used to make a broth on the following day (Cappellini, 2009). Consistent to this, cooking skills allow consumers to make better use of leftover ingredients, preventing food waste (Lyndhurst, 2007). Cooking competencies also help avoid burning food and cooking excessive quantities that are then wasted (Mondéjar-Jiménez et al., 2016).

3.2.2 Physical Affordances

The amount of storage space, the size of the refrigerator, and the colour, size and material of plates used for servings all influence consumption behaviour in the kitchen (Block et al., 2016). Consumers may forget to consume items close to the expiration dates if newer purchases are stored more visibly in their inventory (White et al., 2016).

While we found no research investigating the effect cooking appliances on food waste, we would expect superior kitchen equipment to facilitate cooking competencies, which in turn can decrease food waste (Mondéjar-Jiménez et al., 2016). Particularly, we would expect that simply having access to easy-to-use tupperware with which to store leftover foods would encourage leftover re-use.

Finally, the physical appearance of food items, such as fruit and vegetables or damaged packaging, affects consumers decisions to dispose of the item, even when still edible. Consumers fear imperfect food might be unsafe to eat (White et al., 2016).

3.2.3 Social Regulation

Social conventions, social representations and culture constitute another layer that influences behaviour in the consumption stage. Social representations such as expectations from a good host or provider channel behaviour that can cause food waste. People want to avoid feelings of guilt or failure to meet others' expectations of what it means to be a good host or provider, leading them to over-prepare meals and serve excessively big portions (Graham-Rowe et al., 2014). Additionally, the desire to be a good host and maximize time with guests, prevents consumers from storing left-overs properly after consumption (Graham-Rowe et al., 2014). Food is left un-stored while guests are in the house, and later is thrown away due to fear of food-illness (Graham-Rowe et al., 2014).

Lastly, social norms surrounding leftovers themselves may be highly influential. Some groups may see leftover food as “dirty” and even consider it shameful to reuse (Lazell, 2016). Specifically, once food has been designated as “waste” it can becomes socially unacceptable to consume (Nguyen, 2014).

3.2.4 ICT Solutions

ICT that offers consumers an overview of their inventories (such as *NoWaste* and *Plus Fridge Pal*) can prevent food from being forgotten and left to expire. Such applications may also help interpret labels correctly and recognize the freshness of food.
Additionally, mobile applications such as *Plant Jammer* may suggest recipes to use up food which is soon to expire. These recipes can also suggest the correct number of portions to prepare to avoid food waste. Lastly, apps can also be used to create social awareness about the impact of food waste, creating a social value for sustainable behaviour. Within the context of leftovers, the above functionalities may help reduce perceptions of health risks and distaste by displaying positive information about the nutritional value of leftovers as well as recommending simple ways in which to turn leftovers into the next tasty meal.

3.3 Disposition

Disposition, as we have defined it, occurs once consumers have decided not to keep certain foods. Generally, individuals are faced with the choice to throw food in the garbage, recycle it (for example by composting) or give it to another person. The installation most relevant for disposition behaviour is the kitchen, although in the case of food sharing, the relevant physical space can extend to include spaces where food is exchanged between strangers, including digital spaces associated with such practices (cf. Farr-Wharton et al., 2014).

3.3.1 Embodied Competences

Mixed findings exist regarding the implications of recycling food waste behaviour. Composting behaviour could create backfire effects, with 41% of a sample of U.S. households reporting that, because they compost, they aren't bothered by wasting food (Neff et al., 2015). On the other hand, a study of food waste across the EU-27 countries found that individuals who report sorting their waste also report significantly lower levels of food waste (Secondi et al., 2015). Further research is thus needed to determine whether composting is positively or negatively associated with actual food waste.

Food sharing - both within and beyond the nuclear family - has been documented and explained across a large variety of settings. Yet the prevailing theories are ill-suited to explain practices of giving surplus food to strangers outside the household (see Harvey et al., 2019 for discussion). Nonetheless, qualitative research suggests that once food has been designated as “waste” or “leftovers” it immediately becomes less appealing to consumers, which contributes to an aversion to accepting food from strangers. (Cappellini, 2009; Lazell, 2016).

3.3.2 Physical affordances

Due to the large gap between intention and actual behaviour in the area of household food waste, contextual factors may be more influential than individual beliefs in preventing food waste (Schanes et al., 2018). In the context of composting, simply providing households with a receptacle for separated food waste is much more effective than raising awareness in encouraging food composting behaviour (Bernstad, 2014).

We found no research on the influence of the physical environment on food sharing behaviour relevant for an urban setting. Nonetheless we expect this to be highly relevant, particularly for sharing food between cohabitants in a flat. For example, having a designated “shared shelf” in the fridge, where cohabitants can leave food that is free for anyone to use, may encourage food sharing within the household. Note that simply sharing food within the household does not by itself lead to a decrease in food waste. Environmental attitudes, household food management skills and general attitudes towards collaboration are important enabling factors in order for food sharing practices within a household to translate into food waste prevention (Morone et al., 2018).

3.3.3 Social regulation

Social norms surrounding leftovers can act as obstacles to food sharing behaviour. Some groups may see leftover food as “dirty” and even consider it shameful to reuse (Lazell, 2016). Specifically, once food has been designated as “waste” it becomes socially unacceptable to consume it (Nguyen, 2014). Lazell (2016) found that in a UK university context, prior social relations between students were crucial for enabling the trust necessary to sharing food. While Kniazeva and Venkatesh (2007) have argued that sharing food is associated with shared identity formation and forming social relations, Lazell (2016) found that in practice, the simple desire to share food is not enough to justify forming social bonds strong enough to enable food sharing behaviour. Similarly, sharing food with neighbours and the wider community is likely to depend on notions of common identity and trust shared with those individuals (c.f. Farr-Wharton et al., 2014).

3.3.4 ICT solutions

While the effect of composting on food waste are ambiguous, sharing food - albeit facing several challenges - presents a great opportunity to reduce food waste. (Farr-Wharton et al., 2014; Lazell, 2016). To encourage food sharing specifically, applications need to not only establish a digital marketplace in which to exchange food, but also have to alter the social norms surrounding food waste and help build relationships between food sharers. Within the context of flatshares, mobile applications can potentially reinforce a social norm of sharing food with flatmates by notifying all residents whenever new food has been added to the inventory for everyone to use. In moving beyond the household, establishing trust and social bonds between food sharers is especially important. We see two main ways in which ICTs can achieve this. First by leveraging insights from Social Identity Theory (Turner et al., 1979) and creating a salient in-group identity, for example by emphasizing that food is being shared with members of the same local neighborhood. Secondly, trust can be created by allowing users to rate and review the digital profiles of other food sharers (Sparks, & Browing, 2011). Taken together this may help overcome the barriers associated with food sharing and even create new persistent relationships between agents committed to reduce their food waste by sharing (Harvey et al., 2019).

4. Solution

Based on the solutions suggested at each food waste stage, we have distilled a list of 12 key features with which mobile applications can help reduce food waste (see appendix). By integrating these 12 features, we propose four major functionalities, which, when integrated into a single mobile application, may scaffold consumer behaviour at each food waste stage to optimally reduce wasteful behaviour: 1) Inventory management, 2) Smart recipes, 3) Portion ready food delivery, 4) Food sharing hub.

4.1 Inventory management

The ideal mobile application should allow users to log all food items in their inventory, and to create smart grocery lists based on this information. Additionally, the ideal application would present information for each food item on the grocery list, explaining how to properly store the item, how to tell when it has gone off, as well as how frequently this particular food has been wasted by the user in the past. Such functionality would facilitate proper meal planning and help reduce over-purchasing in the supermarket, while also preventing premature disposal due to ineffective storage or wrongful assessment of food safety. The app would predict when certain food items are due to expire (for example based on information on food type and expiration date entered by the consumer) and alert the user before this happens, so they can incorporate these ingredients in the next meal. By also displaying historical data on food items thrown out in the past, we hope to further raise awareness of the food (and money) wasted by consumers every week. Of course, the success of this functionality depends on users actually logging their inventory. By allowing users to make grocery lists within the application and adding any item which has been ticked of that list directly to the inventory, we could reduce the effort connected with tracking ones inventory and capitalize on the habit of making grocery lists, which already exists for many consumers (Neff et al., 2016).

4.2 Smart recipes

Another important factor for preventing food waste is cooking capability (Principato, 2018; Schanes et al., 2018). Based on the items on the inventory list that are about to expire, the ideal application would suggest recipes for meals that can be prepared with the available ingredients as well as suggest complementary items to buy, if necessary. The recipes will be tailor-made depending on the amount of servings, time available and level of difficulty. This will enable consumers with low cooking skills to use all the ingredients they buy, in the correct amount, as well as avoid any cooking mistakes that may lead to food waste. Additionally, the application would let the user log whether all of the prepared food was eaten. If not, it could add the leftovers directly to the inventory list and automatically suggest ways to use them in future meals. This would help consumers to reappraise leftovers as desirable and avoid unnecessary waste at the consumption and disposition stage (Cappellini, 2009).

4.3 Food sharing hub

As discussed, food sharing has the potential to prevent a lot of food waste, but also faces major challenges in overcoming social norms related to accepting leftover food from strangers (Lazell, 2016). The ideal app should include a food sharing hub, which not only acts as a marketplace for users to donate and pick up leftover food items, but also creates social ties between regular food sharers. We propose that it should have features both geared towards food sharing within a shared flat, as well as for the broader neighbourhood. Within a flatshare, the food sharing hub would be linked to each user's individual inventory list. Users should be able to drag individual food items to a shared inventory list, notifying all cohabitants of the flatshare. To encourage food sharing outside the flat, we suggest letting users set up personal profiles with pictures and having others rate the quality of the food shared. While this runs the risk of discouraging users from sharing food in the first place, we believe transparent ratings to be an invaluable tool in fostering trust between strangers, which in turn is necessary for food sharing (Lazell,

2016). Secondly, the app should emphasize that food is being shared with people in the neighborhood, to further increase social cohesion and trust between users.

4.4 Portion-ready food delivery

Finally, we propose to integrate our mobile application with a portion-read food delivery service such as *Hello Fresh*. Users would be able to plan meals for the upcoming week and get the ingredients delivered directly to their door in the perfect quantities. This feature would allow consumers to overcome the diversification bias in the supermarket, as they are offered a wide range of choices daily and would equip them with the necessary tools and information needed to correctly prepare meals. The fact that the ingredients are portioned would also result in fewer leftovers which may be wasted.

Ideally, this function could be integrated with the other three functionalities. Meals could be suggested based on food items already found in the inventory. Once the ingredients for the planned meal arrive, they could also be added to the inventory automatically, and the matching recipe activated.

5. Discussion and Limitations

Throughout this essay we identified sources of food waste within urban households of young consumers. Using Installation Theory, we discussed the physical affordances, embodied competences and social regulations that influence consumers throughout the process of acquisition, consumption and disposition. We focused our analysis on the supermarket and kitchen, understanding them as the most important installations where these processes tend to occur. Based on the analysis, we proposed an ideal mobile application that can help reduce food waste by scaffolding relevant behaviour. This ideal app is built around four key functionalities: 1) A comprehensive inventory management system, 2) a smart recipe generator, 3) a food sharing hub, and 4) a portion-ready food delivery service.

Possibly the most important limitation of our solution is that it depends entirely on consumers' willingness to use the mobile application. Real world ICT solutions face the threefold challenge of beneficially scaffolding user behaviour while encouraging enough individuals to regularly use the application and somehow being financially sustainable. We have here only considered the first of these three challenges. Secondly, while we have identified key behaviours that contribute to household food waste, counteracting them is not necessarily guaranteed to reduce total food waste. Treated in isolation, some measures may only displace food wasted. For example, by cooking smaller portions at each meal, one may waste fewer leftovers, but end up with more raw ingredients which spoil in the fridge. Any kind of reduction in household food waste needs to eventually translate into a reduction in food acquisition by the household. And even then, saved food may still be wasted earlier in the supply chain, for example because supermarkets keep ordering the same amounts.

Ciaghi & Villafiora (2016) have commented on the inherent difficulty of saving food at the household level - due to the food items being kept in small quantities and very close to their expiration date. We agree that it will not be possible for a single mobile application to tackle household food waste on its own, but see it as a starting point in facing a problem that requires many different approaches being enacted in parallel.

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7. Appendix

Functionality	Feature
Smart Inventory	Create grocery lists based on past consumption and current inventory
	View information on how to store purchased items correctly
	View information on when purchased items should actually be disposed
	Have clear overview over available foods in the inventory
	See statistics on past food waste, including monetary and environmental impact
Smart recipes	Find recipes based on inventories and soon-to-expire food
	Track leftovers and find recipes for creative reuse
	Adjust recipes for ideal portions for every user
Food-sharing hub	Manage common inventory for food shared within flat
	Access digital marketplace to share leftovers with members of the wider community
	See and rate personal profiles of other food sharers
Portion-ready food delivery	Order ingredients for specific meals to be delivered straight to the door

Table 2: 12 key features app to reduce consumer food waste