How to Nudge *In Situ*: Designing Lambent Devices to Deliver Salient Information in Supermarkets

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ABSTRACT

There are a number of mobile shopping aids and recommender systems available, but none can be easily used for a weekly shop at a local supermarket. We present a minimal, mobile and fully functional lambent display that clips onto any shopping trolley handle, intended to nudge people when choosing what to buy. It provides salient information about the food miles for various scanned food items represented by varying lengths of lit LEDs on the handle and a changing emoticon comparing the average miles of all the products in the trolley against a social norm. When evaluated *in situ*, the lambent handle display nudged people to choose products with fewer food miles than the items they selected using their ordinary shopping strategies. People also felt guilty when the average mileage of the contents of their entire shopping trolley was above the social norm. The findings are discussed in terms of how to provide different kinds of product information that people care about, using simple lambent displays.

Author Keywords

Decision-making, in-the-wild study, persuasive technology, tangible embedded interaction, mobile devices, nudging

ACM Classification Keywords

H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces – user-centered design, evaluation /methodology, prototyping.

General Terms

Design, Experimentation, Human Factors

INTRODUCTION

Increasingly, we are being told about the costs and benefits of food choices. Consumer surveys also indicate that shoppers are taking heed, wanting to know more about the global consequences of their consumer decisions [28]. In response, a flood of information is becoming available in a variety of forms: online, on food labels, in information leaflets and books, and now appearing as smartphone apps, aimed at informing the consumer so that better decisions can be made while shopping. But all this information risks overwhelming the shopper trying to navigate a complex store environment in a hurry, possibly leading to the opposite outcome – poor decisions made without the proper input. How can product information be consolidated, pruned down, and presented to supermarket shoppers in an easy-to-understand and meaningful form that will actually help them make better choices on the basis of values they care about? How might UbiComp technologies be designed to provide this?

We are interested in how everyday decisions can be nudged using simple technologies that are *lambent* (that is, those that have lights that flicker gently over a surface).

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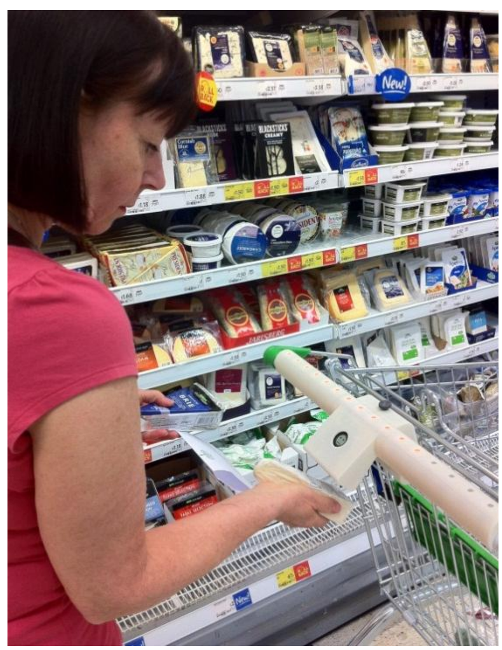

Figure 1. Shopper making a decision with respect to the origin and organic properties of a product by scanning the barcode on a block of cheese in her right hand while holding an alternative brand in her left

The goal is to provide just enough salient information about certain product properties to help shoppers make more informed purchasing decisions in supermarkets. Our aim is to develop a mobile, easy-to-use display that can convey relevant information that is difficult to find on a label *in situ* when doing a weekly shop in a supermarket. In the research presented here, we chose to display information about food miles (i.e. how far the food product has travelled to arrive at the supermarket) as well as information on whether or not the product is organic.

Our approach starts from the perspective of ecological rationality, which explains how people make reasonable decisions given the constraints of limited time, information and computational resources that characterize most real-world situations [20, 23]. Research shows that many decisions are made using 'fast and frugal' heuristics – short-cut strategies where people simply ignore most available information and focus on the highly useful and prominent information, processing it quickly. Example strategies used for *in situ* decision tasks include: making choices on the basis of what is recognized [3]; looking for options until one finds one that is 'good enough' [24]; and choice heuristics that seek as little information as possible to determine which option should be selected [12]. Often people make a decision based on a single reason as this strategy is quick and simple and avoids having to weigh up trade-offs between multiple and potentially conflicting options [6]. For example, in a supermarket shoppers tend to make snap judgments based on just a few salient cues (low price, recognized brand and attractive packaging) and they rarely take time to read product information labels [25].

Taking this real-world behavior into account, we developed a novel lambent display that provides product information in a brief, highly salient and 'glanceable' form. Our design approach was born out of the need for an embedded device that is mobile, self-contained and easy to use in a supermarket. For this we built a fully functional independent device that clips on to a shopping handle and comprises a small display, a series of LEDs that are connected to an embedded barcode reader and other electronics (Figure 1). When a shopper scans a product, relevant information is displayed together with feedback that shows how the averaged aggregate of the entire shopping trolley compares to a social norm. An in-the-wild study was conducted to evaluate how shoppers used the lambent display to inform their selection of food items. We describe here the design process used in developing the lambent handle and our study findings.

RELATED WORK

Ubiquitous computing approaches for augmenting the shopping experience are abundant. They range from simple applications available on popular smart phone platforms to full-fledged hardware setups integrated into supermarket trolleys. On the mobile side, several apps currently exist that enable shoppers to scan product RFID tags or barcodes on enabled mobile devices and receive information, reviews and recommendations, such as the Mobile Sales Assistant [14], Mobile Prosumer [15], APriori [16], GoodGuide [4], Google Shopper [5] and RedLaser [13]. These applications provide the user with star ratings and price comparisons as the primary decision making inputs. While it is sometimes helpful to receive such information when one is making a purchase decision, at other times it can be overwhelming to be exposed to this flood of often contradictory advice from other consumers. The iGrocer [18] takes this approach a step further and provides the user with personalised recommendations based on the user's own predefined health concerns. It is particularly suited for elderly users and those with critical health requirements such as allergies.

Other apps have been designed based around shopping lists. Nurmi et al. [11] developed a system that maps shopping lists written in natural language with actual products in a grocery store. They developed the system using nine months of shopping basket data from a large Finnish supermarket. A prototype for creating shopping lists using multiple input devices such as desktops, smart phones, and landline phones in multimodal formats such as text, audio, still images, video, and annotated media was introduced by Jain et al. [7]. Wu et al. designed a new architecture enabling efficient integration between mobile phone applications and web services to implement a mobile shopping assistant [27].

Recently, hardware-based shopping assistants have also begun appearing. The IRL SmartCart [9] is a fully implemented augmented shopping trolley that assists the user by facilitating navigation and making it easier to find the products they are looking for. The Context-Aware Shopping Trolley [1] assists a user in finding the products on their shopping list. All products in close proximity to the user's shopping cart are highlighted on a map and the shopping list gets automatically reordered so that the nearest products are at the top of the list. If the user is near to an item on their shopping list, they get an acoustic signal as a notification.

These systems provide users with interactive information meant to guide them to the products they want and aid them in making their decisions. A different approach to augmenting the shopping experience is to provide users with information meant to nudge them towards making a decision they would have not otherwise have made. For this type of augmentation, detailed displays of information that require complex user interaction may be ineffective in real-world settings, as users would likely ignore them. Systems that hope to *change*, rather than facilitate, a user's behaviour are thus more likely to succeed when they provide a very simple mechanism for interaction and display a very limited amount of information that targets specific desired behaviour and is difficult to ignore.

An example of such a system is the iCart [10], an augmented handle bar built into a shopping trolley that provides simplified nutritional information to the user about the products they put into their shopping cart. The iCart aggregates nutritional properties of each product and tells the user which of three health categories it falls into. It was implemented using a Wizard of Oz technique, and an evaluation of the device showed that by providing simple recommendations at the right moments, users were susceptible to changing their decisions.

Recommendations aim to change behaviour by influencing what people consciously think about. Nudging is an alternative behavioural change technique which works by altering the context in which people act. Recommendations stimulate conscious reflection, whereas nudges typically influence the automatic brain system and operate unconsciously [22]. A number of other systems have been developed to nudge people towards behaving in a particular way in contexts other than the supermarket. Rogers et al. [17] showed how an ambient display using a combination of a kinetic sculpture and twinkling LEDs can push people to take the stairs rather than use an elevator when moving between floors in an office building. Other examples target energy consumption [19] and physical exercise habits [2].

THE LAMBENT SHOPPING HANDLE

We begin by describing the motivation for and design of our clip-on lambent shopping trolley device. Then we describe details of an *in situ* user evaluation that took place in one of the main supermarket chains in the UK.

Handle Design

The lambent shopping handle is a tangible mobile shopping device that has been designed for *in situ* use within the supermarket environment. Figure 1 shows how the device directly clips onto any supermarket shopping trolley. In contrast to the iCart [10], the lambent shopping display makes salient information which is difficult or impossible to determine from a product's label, such as food miles or whether it is organic. Furthermore, it uses simple and subtle nudging effects, rather than providing recommendations, to influence consumer behaviour: i) providing a few pieces of salient information about a product's properties; ii) showing how the average food miles of all the selected items in the shopping trolley relates to a norm. Thus, nudging in this context means providing additional information in a low-cost way, naturally embedded in the decision task, so as to influence behaviour in that task.

The design focus was to create a fully functional device in a self-contained portable shell which could easily be used in a supermarket. In essence, the device is a digital shopping trolley handle. It is designed to clip onto any shopping trolley and display information while still functioning as a graspable handle. The limited space required us to develop a compact design. We chose to build the trolley handle using .NET Gadgeteer – a modular hardware platform. This platform is based on a small but powerful embedded processing unit to which a number of electronic modules can easily be connected. Modules provide additional capabilities for input, output, power, display, sensing and actuation. They can be connected and disconnected using a standardized interconnection mechanism, making the hardware very flexible. We programmed the hardware using the high-level C# object-oriented language.

In large part, the lambent device was built with the hardware modules pictured in Figure 2: the *Battery* is connected to the *Power* module, which can be used to recharge the battery through a *USB connector*, and provides a mechanism to program the device from a PC; the *LED* module can be programmed to display a set colour, or to fade between different colours; the *Button* is used to provide a way for the user to indicate that a previously scanned product has been removed from the basket; the *Barcode Scanner* is used to scan in product barcodes; the *Mainboard* provides core processing functionality; the *SD Card* stores and references the product database; the *Ultrasonic Sensor* activates the *Barcode Scanner* when objects are within range; the *Display* module provides a 128x128 pixel resolution graphical TFT display.

All these modules are standard components of .NET Gadgeteer, except for the Barcode Scanner. For this prototype we adopted an off-the-shelf OPR-3201 laser barcode scanner, which we adapted to work as a custom module. The scanner communicates with the Mainboard through a USB interface, appearing to the Mainboard as a USB keyboard. An additional digital output on the Mainboard is connected to the scanner as a control signal to start and stop the barcode scanning process.

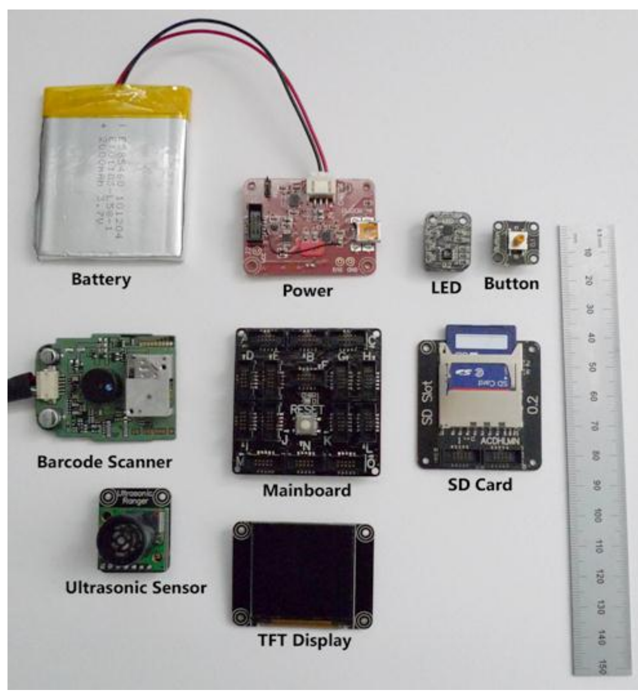

Figure 2. .NET Gadgeteer components and bespoke barcode scanner hardware used in the lambent handle

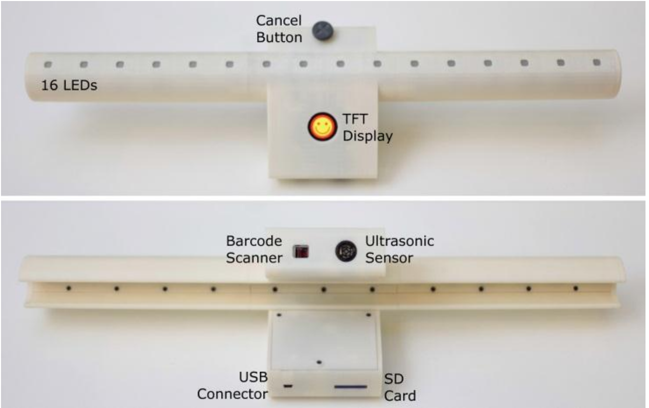

Figure 3. Clip-on lambent shopping handle shell 3D-printed in high definition with embedded electronics: interaction model (top), hardware modules visible (bottom)


Figure 4. A side view of the lambent shopping device showing how it clips on standard supermarket trolleys

The assembled system contains 16 of the LED modules configured as shown in Figure 3. The LED modules can be daisy-chained in series and individually addressed. In our prototype, the LED chain is used as a simple one-dimensional display providing user feedback. The prototype is fully functional and was designed to clip onto an ordinary supermarket trolley handle (see Figure 4).

Handle Interaction Model and Design Rationale

We chose to use the lambent device in our first *in situ* study to display information about a product's food miles (how far a product travelled to the store) as well as whether or not it is organic. The rationale for this choice derives from a pilot study we carried out to help us understand how people shop [8]. Eleven participants (25 to 60 years of age, 4 female, 7 male) took part in this pilot study where we observed people carrying out their weekly shop. These participants reported that price was the most important factor in their decisions, but the majority also reported a concern with the origin and organic properties of products. They described the origin in terms of three categories: local, not far (often from countries in Europe) and far away (countries that were outside Europe). We applied this classification to our lambent device design. In addition to displaying an individual product's mileage using the LEDs, we also displayed an iconic representation of how the average mileage of all the products in the trolley compares to a predetermined social norm.

The lambent device was thus programmed to provide information about four product properties:

1. *Individual Product Mileage* – represented as a number of orange or green LEDs (see dimension 3 below) momentarily fading in from left to right whenever a product is scanned. The first five LEDs represented local products; the next five indicated that the product came from somewhere within Europe, and the rightmost five indicated that the product travelled from further parts of the world, e.g., South America or the Far East. The precise number of LEDs corresponded to an approximate mileage between the UK and the country of origin; for example, France would have six lights whereas Spain would have eight (see Figure 5).
2. *Average Trolley Mileage* – represented as a number of orange LEDs statically lit up from left to right in-between the product scans. The lambent handle continuously calculated and displayed the average mileage of all the products scanned and added to the trolley (see Figure 5). (The *Cancel Button* was pushed when the user wanted to remove the last scanned item from the trolley – see Figure 3, top.)
3. *Organic* – indicated by green LEDs lighting up for the product's *Individual Product Mileage,* with orange LEDs used for non-organic products (Figure 5, bottom).
4. *Social Norm* – indicated by an emoticon corresponding to the relation between a social norm and the *Average Trolley Mileage*. We pre-programmed this to fit the study scenarios described below: There are 3 modes – happy, neutral and sad – and by default, at the start of the study all participants began with the happy emoticon. If the average trolley mileage reached 10 LEDs, the social norm display would show an emoticon of a neutral face, while if there were 13 lit LEDs, the emoticon display would become a sad face. The participants were thus encouraged by the emoticon display to maintain an average mileage that corresponded to nine LEDs or less (see Figure 6).

The rationale for using LEDs as a way to show distance rather than using another representation such as whole numbers is because we believe shoppers can understand the mapping from LEDs to distance better than other displays. People are already overloaded with information and having another number to look at would not be so effective. The traffic light product goodness measure displayed by supermarkets on food labels has not yet proven successful either.

We constructed a database that contained all the product varieties in our shopping lists, described below. We used an off-the-shelf barcode scanner to scan in product barcodes. In total we scanned in 113 barcodes of products in our chosen supermarket and then used the supermarket website to generate annotations for individual products detailing its food miles and whether it was organic.

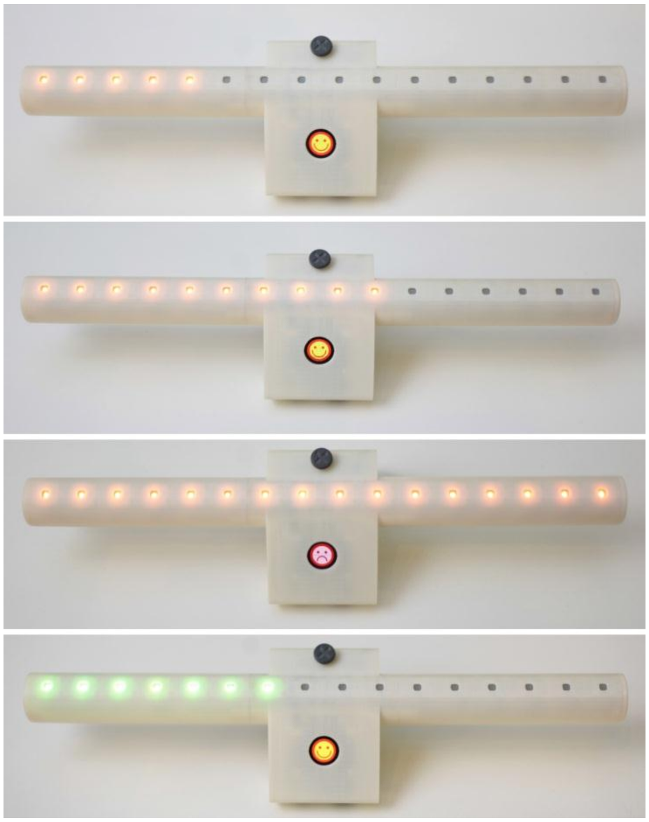

Figure 5. The LEDs light up from left to right to indicate product mileage (origin), in green when the product is organic or in orange if not. From top to bottom: local (UK), not far (European), far away (rest of the world), organic European

EVALUATION

We asked 18 people to go shopping in a large local supermarket from a well-known UK chain. We observed how they shopped and how they made decisions *in situ.* Each participant was asked to shop in two different ways: (i) using an ordinary shopping trolley; and (ii) using the same shopping trolley with our clip-on lambent device. We compared the two conditions to see whether using the lambent device nudged people into buying different products than when they used an ordinary shopping trolley.

The specific research questions we aimed to address were as follows:

- Do people use the lambent shopping handle when it is available to help them make decisions?
- Does the lambent display nudge shoppers towards more environmentally friendly product choices or do shoppers continue to choose the products they habitually buy?
- If the lambent device does change consumer behaviour, is the nudge a result of the social norm, the salience of the product information or a combination of the two?

Participants

Eighteen participants took part (8 female and 10 male, aged 23 to 65 years). Participants were recruited via a public notice board and came from a wide variety of backgrounds: librarians, catering staff, lecturers, researchers and other professionals. None of the participants had any prior experience of using the lambent device. Participants received a £10 gift card on completion of the experiment.

Procedure

We conducted a semi-controlled within-subjects study in a large 7000m^2 supermarket in the UK. In the nudge condition participants shopped using the lambent shopping handle. In the control condition participants shopped using an ordinary unmodified shopping trolley. Each participant completed two shopping trips, one in each condition, with the order of conditions counterbalanced across the participants.

We generated two average-length shopping lists (12 items each) as shown below. When selecting items for the shopping lists, we tried to pick products that varied in their food miles and organic properties. For each product on our shopping lists, there were at least two choices for origin, for example, local (UK) and close (European) or local (UK) and very far (rest of the World). However, we also had a few products where the country of origin was less important, such as Brie cheese where all the alternatives came from France.

Since the participants were not shopping for themselves, we created a short scenario to go with each shopping list to give a context and purpose to their shopping trip:

Scenario 1: *"You have some friends coming over to stay for the weekend who run a website promoting an environmentally aware and organic lifestyle. They are very particular about what they eat. You have offered to stock your fridge and pantry with food for them during their stay and they have mentioned that they would like the following things. Please make your decisions as you normally would when shopping, but consider the needs of your guests."*

Your shopping list is as follows:

1. *Sparkling water (1 bottle up to 2L)*
2. *Cranberry cordial (1 bottle)*

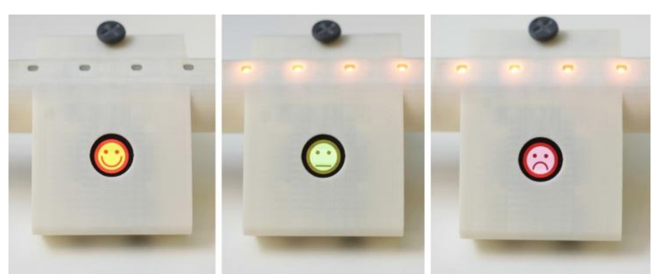

Figure 6. The TFT screen displays an emoticon showing how the participant's choice behaviour compares to the social norm. Left to right: below norm level, at norm, above norm

3. *Yeast extract (spread – 1 jar)*
4. *Maple syrup (1 bottle)*
5. *Anchovy fillets in olive oil (1 small jar)*
6. *Brie cheese (1 piece)*
7. *Full fat spreadable soft cheese (1 tub)*
8. *Demerara sugar (1 bag)*
9. *Canned prunes (1 jar)*
10. *Cucumber (1 piece)*
11. *Chillies (1 bag)*
12. *Dark chocolate (1 bar)*

Scenario 2: *"You have an older relative coming over to stay with you for a few days. She is a member of the Green Party and always shops for organic food. You have offered to stock your fridge and pantry with food for her during her stay and she has told you that she would like the following things. Please make your decisions as you normally would when shopping bearing in mind your relative's interests."*

Your shopping list is as follows:

1. *Still water (1 bottle up to 2L)*
2. *Fresh cranberry juice (1 carton)*
3. *Clear honey in a 340g or smaller jar*
4. *Chocolate spread with hazelnut (1 tub)*
5. *Tuna in spring water (1 can)*
6. *Fresh Mozzarella (1 piece)*
7. *Unsalted butter (1 cube)*
8. *Crunchy peanut butter (1 jar)*
9. *Pears (1 bag)*
10. *Spring onions (1 bunch)*
11. *Mushrooms (1 box)*
12. *Chocolate Ice Cream (500ml tub)*

Each participant used both shopping lists, one in each condition. The lists and conditions were counterbalanced so that half the participants used the one list for the nudge condition, and the other half used that list for the control condition. The participants found the scenarios to be quite realistic and some could even think of a real friend or a relative who fit these descriptions quite closely. Some participants even went further than we expected in the role designated for them in the scenario saying, *"I don't want the guests to see that I bought them the cheapest bottled water"* when asked why they went for a branded product. In addition users were asked to consider their own shopping habits and how much they would be prepared to compromise for their guests. For example, one participant said, "*I don't buy unsalted butter usually, so since I'm buying for a guest, I'm getting the cheapest because I don't know how much I'm gonna use.*"

Prior to the study, we asked the participants 20 questions based on the Food Choice Questionnaire [21], including some that focused on their attitudes towards buying local and organic products.

After a quick demo and a 5-minute hands-on tutorial on how to use the lambent shopping handle, participants had no problem following the scenarios and shopping lists or using the lambent device.

We recognize that locally grown food is not necessarily 'greener'. For example, growing food in less than ideal local conditions can sometimes result in more carbon emissions than importing food. [29]. However, CO2 emissions are not yet included on UK product labels, and to carry out this evaluation study we had to choose product information that is currently displayed on product labels. Importantly, the lambent device is not restricted to displaying information about food miles and whether a product is organic; it is a far more general system and can display one piece of ordinal product information (the degree to which it has a property) and one piece of nominal product information (whether or not it has a certain property).

In total, we conducted 36 shopping trips, two with each participant, and each trip lasted between 20 and 50 minutes. The participants were not required to check out and purchase their items, which were instead returned to the shelves at the end of each shopping trip.

We captured audio, images, and occasionally video, in both conditions. We automatically logged all interactions with the lambent device and noted what participants chose to buy in both conditions. However, due to a combination of human and software error, the control condition product choices made by one participant were not recorded and could not be recovered. In addition, given the *in situ* nature of the study, real world conditions caused some data collection problems such as certain types of products being sold out during some shopping trips. However, the majority of products chosen by participants were successfully logged, which was sufficient for our analysis.

RESULTS

We were interested to see whether people would use the lambent shopping device to help them make decisions or would continue with their usual shopping practices, which could involve reading the label or purchasing items they have purchased before. Contrary to our original expectations, we observed some differences in participant consumer behaviour when they used the device. In particular, when participants were given the lambent shopping handle, for every two items they chose to scan and place in their trolley, they also scanned at least one additional item on average to make sure it did not have lower mileage (people made about 1.5 scans per each product they chose to purchase). The reason often given was that users were unable to spot the product origin on the label: *"I wouldn't know just by reading the label how far it has travelled."* Based on what they discovered with the lambent shopping handle, they sometimes changed their mind (*"I changed my mind about the Lurpak butter"*) and chose more local.

Participants whose experimental sequence involved completing the nudge condition first and then following it with the control condition had an interesting reflex effect, whereby they leaned towards their trolleys trying to scan the product only to discover that the lambent shopping handle was no longer clipped onto their trolley. After this discovery, we expected most participants would simply read the label to find the information that the trolley would have shown. However, to our surprise, they tended not to rely on the label, instead choosing products by price, taste or brand recognition, and ignoring food mile information.

In order to run more reliable quantitative analysis on our data we dropped the data for those products that had been compromised. For example, products where at least one product alternative was frequently sold out, thus limiting participant choice, and products for which there was a large number of missing data due to other sources of error. In total we removed six products, three from each scenario. These were: cranberry cordial; cucumbers; prunes; chocolate ice cream; mozzarella cheese; and spring onions.

Decision Making *In Situ*

We initially compared the average food miles for each of the 16 products across the two conditions. One item, still water, had the same average food miles in both conditions, but all other products showed a difference. A binomial test showed that 13 products had significantly lower mean mileage in the lambent device condition (p=0.05) than in the control condition (Table 1). Thus with most products there was a significant nudge effect to select items with lower food miles when using the lambent shopping handle compared to the control condition.

Products	*Mean food miles (using lambent device) max = 16*	*Mean food miles (control - normal trolley) max = 16*
Anchovies	10.4	12.4
Sugar	5.9	14.1
Butter	3.4	7.5
Cranberry Juice	4.5	10.8
Honey	5.9	12.3
Brie cheese	10.6	10.5
Soft cheese	11.0	11.1
Dark chocolate	12.0	10.6
Sparkling water	5.3	6.0
Still water	4.3	4.3
Chocolate spread	5.0	5.8
Peanut butter	9.3	10.0
Mushrooms	5.0	9.1
Pears	12.3	13.5
Tuna	15.6	15.5
Chillies	15.0	15.2
Maple syrup	6.9	5.4
Yeast extract	3.4	3.9

Table 1. Differences in mean food miles for each product in the two conditions – measured in terms of the number of LEDs lit up on the lambent device

The largest differences between the conditions were for products where there was a bimodal choice of food miles. For example, the type of sugar that users were asked to pick was harvested either in New Zealand or in the UK – there were no mid-range alternatives that originated in Europe. Similarly for cranberry juice, there was a choice of local produce or North American.

Two products that displayed similarly diverse mileage ranges but displayed no significant nudge effect in user choice were maple syrup and yeast extract. From our observations, we noted that participants usually had strong opinions about these products: *"[Picked the largest jar of Marmite brand yeast extract on the shelf]…it has got to be Marmite, because it has the right taste and I love it! I tried Vegemite [the alternative brand] when I was in Australia, but it has a strange aftertaste…and I picked the largest jar because this is the one I normally buy."* Similarly with maple syrup, people who liked it or had used it before picked the authentic Canadian brand over the local British one: *"I only buy this for Pancake Day, but I always get the proper [Canadian] one.*"

Products where there was only a small difference in food miles between available choices displayed no significant differences between the two conditions in the average food miles of the chosen items. However, we did observe participants making item choices on the basis of a difference of only a few LEDs. For example, soft cheese from France (6 LEDs) and Germany (7 LEDs) only had a difference of 1 LED on the display and participants tended to choose the item with fewer LEDs, unless a large difference in price was seen.

We did not observe any significant difference in the choice of fruit and vegetables between the two conditions. This could be because their origin was often clearly marked on the front of the packaging, unlike for other products where origin information was typically written in small print, if at all, and often on the back of the item.

Nudge Effect

The nudge at individual product level was more prominent in situations where labelling on the origin of the product was more discreet, in small print or absent. With the lambent shopping handle we made this often discreet information more prominent and salient, creating a nudge effect whereby people were making more informed decisions based on the very simple ambient display. As one participant noted: *"Products that light up too much make me think twice*".

Most food mileage decisions were made at the level of how many "lights lit up". Participants either scanned alternative products if they thought there were too many lights or they were simply curious about mileage for other similar products. Often people would choose the products with fewer lights and then consider other factors such as organic properties, the price and the overall quality and appearance of the product: "*Picked cranberry juice because it is close* *and half the price."* and *"Picked the local mushrooms which were not much more expensive."*

We found no nudge effect for organic products based on LED colour (see Table 2). There was a significant effect for honey but in the opposite direction: People bought organic honey less often in the nudge condition. This is due to the fact that the only organic honey available came either from Mexico or from New Zealand. Since organic products are much more prominently labelled as organic, participants in both conditions found it very easy to find organic honey. In the nudge condition, once participants scanned in organic honey, they discovered that it came from far away, and this is when many of them opted for non-organic but local honey instead. Indeed, it was rare that a participant would use the lambent shopping handle to determine if a product was organic or not. One participant highlighted this by saying that: *"Lights for organic weren't very useful."*

In Situ Appropriation

All the participants were happy using the lambent shopping handle. Some particularly liked it and thought it would be useful for their own weekly shop: *"This is ideal for my age [64 female]: it helped not to have to look at the tiny print on the labels. The [lambent shopping handle] also influences my decisions, and I discovered a few new things that I didn't know before, e.g. about British butter."* Others commented on how the lambent shopping handle influenced their shopping behaviour: *"I took the trolley with me into the aisles to scan which I don't normally do."* But people also noted that the device increased the time it took them to select products on the shopping list because they were scanning and checking more items than they normally would: *"... [the lambent shopping handle] slowed me down a bit. I scanned more things."* Overall, the trolley did seem to have an effect on how people shopped and felt about their product choices: *"I did feel really bad sometimes - when the trolley showed high distance."*

The lambent device was less useful for the few participants who always read product labels when shopping: *"I was not using the trolley to get information. I was looking at the distance on the label rather than the trolley."* Participants' choices were also influenced by other properties such as recyclable packaging: *"I chose these spring onions because they were not packaged"* and *"...these mushrooms were in a recyclable box."*

Products	*% Organic (nudge)*	*% Organic (control)*
Honey	12.5	75
Dark chocolate	50.0	90.0
Peanut butter	85.7	100
Mushrooms	71.4	28.6
Pears	25.0	50.0

Table 2. User choices for organic products where available

Other participants were very specific in the brands they chose, and so ignored the lambent device and suggested changes to the shopping list. For example, asked to buy chocolate ice cream, one participant said: *"They don't have Haagen-Dazs chocolate ice cream. I'd rather get another flavour in Haagen-Dazs than chocolate ice cream of another brand."* Price was the predominant factor affecting participants' product choices. Our participants were well versed in looking for bargains and offers and were familiar with the way that this particular supermarket chain displayed price information: *"[Chocolate spread] I chose the closest that looks greener. It's also on offer which is what got my attention."* But despite the influence of all these different factors, people seemed to be able to prioritize and objectively assess what was important to them and how much they were prepared to compromise for their guests in our scenarios: *"Got the local cucumber over organic"* or *"Scanned mushrooms and picked the local which was not much more expensive."* or *"Peanut butter: more expensive but organic."* On the other hand, when no other criterion exists for the decision, people would simply pick the produce with the fewest food miles: *"I don't know the brands, and neither is organic, so I followed the recommendation of the [trolley]."*

Social Norm Influence

The two shopping scenarios emphasised that the guests for whom the participants were shopping were environmentally aware. We configured the lambent device to display how the average food miles of the contents of participants' shopping trolleys related to the guests values, that is, the social norm was relatively low average food miles. We anticipated that if the average trolley food miles were above the social norm, and the participants saw a sad face on the display, then this might lead to them exchanging some of the items in their trolley.

Participants tended to be above the food mile norm at the beginning of their shopping trips, particularly when they began by scanning in high mileage items such as chillies (all of which came from Africa). When they were not below the food miles norm, participants tended to scan in and check the mileage on more products. The emoticons did have an effect on the participants' mood as they continued to shop from that point on: *"The smiley face made me happy and the sad face bothered me"*. Participants did not like the norm feedback when they did not feel that they could change it by selecting different items: *"...it was not useful when there was no choice – it just made me feel bad."*

All participants completed their shopping trips with below average food miles (indicated by smiley icons), and in general they were *"pleased to see that [they were] below the average."*

Usability

Initially, we anticipated that people might have difficulties with the handle interaction, in particular having to rescan the items again before they could remove them from their shopping trolleys. However, there did not seem to be any usability issues with this, except that sometimes people forgot which products they have scanned in and which they no longer needed, and thus had to rescan items that were not in the trolley only to remove them again with the 'Cancel' button.

There was one usability issue related to the 'Cancel' button that emerged: occasionally, when participants were leaning over their handle to place their items into the trolley, this button was accidentally pressed, removing the last scanned item. This is easily addressable by moving the 'Cancel' button to another location on our lambent shopping handle.

DISCUSSION AND CONCLUSIONS

Overall, we found that the lambent shopping handle generated a significant nudge effect, influencing what products people selected. When using the device, 72% of the products had lower mean food mileage than the products chosen when using a normal shopping trolley.

Most nudging seemed to occur instantly as soon as people scanned in the product and glanced at the number of lights that lit up across the surface of the shopping handle. In addition, participants frequently had interesting and strong emotional reactions to the emoticon feedback comparing the social norm to the averaged aggregate of their trolley mileage. On occasions where the social norm was neutral or negative, they were nudged whereby they tried to scan in and check mileage on alternative product choices. Contrary to our expectations we observed no nudging effect for the organic property of products, but this could be because organic products are clearly marked on the label. So there is less need for this information to be made more salient.

Interestingly, while product food miles had a significant effect on consumer decisions, other everyday factors continued to have an influence on the choices participants made. There were frequent trade-offs between choosing an organic product or a non-organic low food miles alternative, as well as between low food miles items and lower priced high mileage items. If items were on special offer, people calculated the trade-off of those, too, for example, choosing a larger jar of Marmite over a smaller more expensive one (in terms of price per unit volume).

The use of cell phones to augment shopping experiences has not been as successful. Commercial applications such as Google Shopper [5], GoodGuide [4] and RedLaser [13] are not useful for supermarket shopping [8]. However, these applications may be more effective when shoppers are looking to immediately purchase a relatively expensive item, such as a DVD player, and they are prepared to spend several minutes getting comparative price data and general reviews. In this situation the demands on a person's attention and the requirement for holding the phone in one of their hands is perfectly acceptable. However, this is not the case when supermarket shopping where decisions are made rapidly and people often use both hands for picking and comparing different products [26]. Barcode scanning using mobile phone cameras is also slower than with purpose built barcode scanners and this could be a further reason why mobile shopping applications have not really been effective.

Product labels do provide some useful information but a number of factors limit their usefulness for shoppers. First, label information is often not salient enough to enable shoppers to make quick purchase decisions. Second, product labels do not provide information on some product properties, for example, CO_2 emissions or food miles. Third, reading every product label is both time-consuming and tedious. For these reasons, shoppers typically make their purchases based on price, brand or packaging. As we have explored here, augmented shopping trolleys that push the right information to the user at the appropriate time could be a better solution for improving immersed user shopping experiences and providing a gentle nudge towards better decisions. Issues of information representation (e.g., bars of LEDs versus pie charts or numbers) and aggregation of data (one product at a time, or the whole cart at once?) need further exploration.

Our future work will focus on understanding not only effective information representation, but also what information in supermarkets would help inform shoppers and nudge them towards the right choices, while also allowing them to decide what these right choices are. This could include individual preferences related to food allergies or other health concerns. Factors such as seasonality, fat, salt content and cost would also be considered. The food mileage that we focused on here for reasons of availability does not necessarily reflect what people care most about; for instance, locally grown food does not necessarily mean a 'greener' choice, especially when it comes to carbon emissions [29]. As more and more information becomes available about carbon footprints of products, studies like ours are needed to determine just how this information can be conveyed to shoppers in ways that influence them without overwhelming them.

In sum, our study has shown that once the information people care about is salient enough, people are generally very good at making the right decisions for themselves – they do not want to see yet another recommender system. What is key in nudging shopping decisions is balancing information frugality and simplicity with enough feedback to enable people to change their choices in a way that they find rewarding and motivating.

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