Healthy Shopping: A Longitudinal Study of a Mobile App to Encourage a Balanced Diet

Jon Bird
Department of Computing
City University London
Northampton Square
London EC1V OHB, UK
jon.bird@city.ac.uk

Daniel Fozzati
UCL Interaction Centre
University College London
Gower Street
London, WC1E 6BT, UK
d.fozzati@cs.ucl.ac.uk

Daniel Harrison
UCL Interaction Centre
University College London
Gower Street
London WC1E 6BT, UK
daniel.harrison@ucl.ac.uk

Paul Marshall
UCL Interaction Centre
University College London
Gower Street
London WC1E 6BT, UK
p.marshall@ucl.ac.uk

UbiComp'13 Adjunct, September 8-12, 2013, Zurich, Switzerland.

Abstract
An imbalanced diet is the primary cause of the majority of non-communicable diseases. In particular, obesity rates are increasing in both the developed and developing world and this disease has been described as a pandemic by the World Health Organization. Many governments provide dietary guidelines, for example, recommended weekly amounts of different food types, but the increasing incidence of obesity shows that these campaigns have not been successful. We developed a mobile app that shows supermarket shoppers the nutritional balance of their shopping trolley. A two-month study demonstrated that the app led to significant changes in participants' shopping habits and an improvement in the nutritional balance of their diets.

Author Keywords
Balanced diet; mobile technology; behaviour change; supermarket shopping.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
A balanced diet is the foundation of good health. It consists of a variety of foods from different food groups and provides the correct amount of energy and

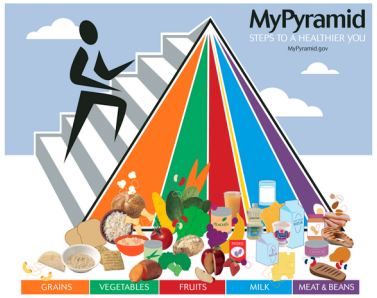

Figure 1: United States Department of Agriculture (USDA) food pyramid visualization of the relative amount of different food types in a balanced diet.

Figure 2: French government food pyramid showing the relative amount of different food types in a balanced diet.

nutrients to meet the dietary requirements of the person eating it. An imbalanced diet is the primary cause behind the majority of non-communicable diseases. For example, the American Heart Association has established a direct causal link between an imbalanced diet and obesity [7]. Since the 1960s, the incidence of obesity has more than doubled in the US, with over 30% of the adult population currently obese [3]. Furthermore, this disease is not limited to the developed world and the World Health Organization reports that obesity is a pandemic afflicting 1 in 7 people globally. If other health conditions linked to obesity (such as diabetes, hypercholesterolemia, stroke, heart disease and certain cancers) are taken into consideration, then an imbalanced diet affects the health of the majority of people in the world. Governments around the world recognize the importance of a healthy diet and provide dietary guidelines, often in the form of product label information or visualizations of recommended amounts of different food groups. However, these information campaigns have not been successful. In the next section we give an overview of the main approaches to providing dietary information as these have influenced the design of the *Healthy Shopping* app.

Visualizing Nutritional Balance

A study by Cowburn and Stockley [2] found that *"consumers seemed to find it particularly difficult to use nutrition label information to place an individual product in the context of their overall diet"*. Governments often use visualizations to convey information about what constitutes a balanced diet. The food pyramid is a common visualization, used in North America, Asia and Europe (Figures 1 – 3), but studies have shown this to be as confusing as product nutrition labels. Cohen et al [1] found that 83% of participants were unable to derive serving sizes from the USDA Food Pyramid (Figure 1). Noland and Mereilles [8] also found that the Food Pyramid, *"doesn't support detection and recognition of differences among good group area sizes and doesn't convey meaning in terms of proportions."* Heath and Heath [4] criticize the Food Pyramid as being *"so hopelessly abstracted from people's actual experience with food – which consists of things like buying groceries and ordering hamburgers in restaurants, not tabulating grain portions – that the message confuses and demoralizes"*. In their book they argue, using a large number of real world examples, that successful behaviour change results from providing people with concrete and specific recommendations.

One way in which governments, such as the US, Canada and UK, try to be more concrete in their diet recommendations is by using the concepts of 'portion' and 'serving' to describe how much of a particular food type should be consumed. For example, the UK has a 'five a day' campaign that recommends people eat five portions of fruit and vegetables every day. Although 'portion and 'serving' are concrete concepts that relate to the amount of food people eat, they are not specific because the amount that people consider to be one portion or serving is highly influenced by contextual cues, such as the size of their plates and serving utensils [9]. Different governments also vary widely in their definition of a portion in their dietary guidelines. For example, in the UK, one portion of fruit or vegetables is 80g, whereas in the US and Canada it is 125g; the UK recommends five portions per day, Canada eight and a half and the US ten. By mass, the US recommends 8750g of fruit and vegetables per week, Canada 7437.5g and the UK 2800g.

Figure 3: Japanese government food pyramid showing the relative amount of different food types in a balanced diet.

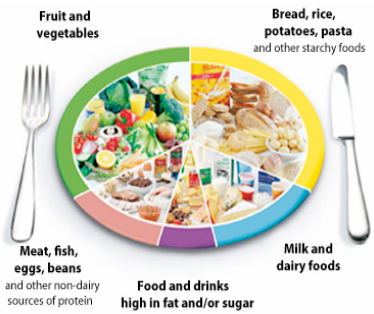

Figure 4: UK government food plate visualization of the recommended amounts of different food types in a balanced diet.

However, one aspect of nutrition advice where there is more agreement is the proportion of different food groups that make up a balanced diet. Most dietary guidelines consist of five food types in the following (approximate) proportions: fruit and vegetables (sometimes presented as separate food types) – 50%; grains (sources of carbohydrates) – 10%; meat and alternatives (sources of protein) – 10%; milk and alternatives (sources of calcium) – 30%; and a small amount of a category covering high sugar and high fat items. Both the US and UK use a *plate* visualization to show the proportion of these food types in a balanced diet (Figures 4 and 5). An advantage of the UK plate (Figure 4) is that food types are represented as 'pie segments', which make it easier to do a size comparison than the shapes used in the US plate visualization (Figure 5). However, although plate visualizations are an improvement on the pyramid designs, being both more concrete and specific, they have not been effective at changing dietary behaviour.

Our hypothesis is that to encourage healthy eating the *context* in which dietary information is received is as important as the information itself: guidelines are more likely to influence behaviour if they are provided when people are engaging in food related activities. We provide support for this hypothesis by describing earlier research where we built a novel device that provided supermarket shoppers with product information and successfully influenced their purchasing behaviour.

The Lambent Shopping Trolley

Supermarket shoppers make rapid decisions about relatively low-cost products on the basis of limited information [6]. The *Lambent Shopping Trolley* (Figure 6) was designed to support the 'fast and frugal' decision-making that characterizes supermarket shoppers [5]. Shoppers scan product barcodes using the handle's built in scanner and two pieces of product information are then shown on a 16 LED display built into the trolley handle. One piece is an ordinal property of the product, for example, whether it has travelled a low, medium or high number of miles to the store and is represented by the number of LEDs that light up. A binary property of the product, for example, whether it is organic or not, is indicated by the colour of the LEDs, with green signaling the presence of the property and orange its absence. A circular display on the handle shows how the average food miles of the products in the trolley (or other ordinal property) compares to an average shopper or other social norm. If the average trolley food miles is above the norm then a sad emoticon is displayed, if this value is around the norm then a neutral emoticon is shown and if it is below average then a happy emoticon appears.

In a supermarket study, 18 participants purchased items from two shopping lists, once with the Lambent Shopping Trolley and once without. The display nudged participants into selecting products that had fewer food miles. They reported that if they saw that their average food miles was above the norm then they scanned more products to find the one with fewer food miles in order to bring their average down. The Lambent Shopping Trolley demonstrates: first, that providing appropriate and salient information at the point of decision making can influence the products that shoppers choose; second, social norms are an effective technique for influencing shoppers' behaviour.

Limitations of the Lambent Shopping Trolley

There were three main limitations of the Lambent Shopping Trolley study. First, although successful in

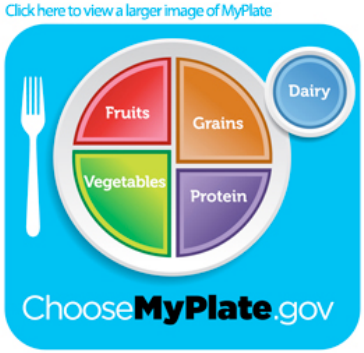

Figure 5: USDA food plate visualization.

nudging supermarket shoppers to change their purchasing behaviour in the short term, it is not clear if this was the result of a novelty effect and whether the change would be sustained over time. Second, participants were limited to purchasing products on the shopping lists we provided because we did not have access to a database of all the products in the supermarket where we carried out the study. Third, if the Lambent Shopping Trolley handle is to be used more widely, then it requires the co-operation of a supermarket chain to pay for more devices to be fitted to their trolleys. It is uncertain whether supermarkets would invest in the technology: first, there is no guarantee it will lead to increased spending by shoppers; second, the information that consumers would like to know is not necessarily the information that supermarkets would like to provide. Furthermore, shoppers might not trust the product information if it comes from a device supplied by a supermarket whose motivation is profit- rather than information-driven.

We now describe a study where we designed and evaluated a mobile shopping app that provides supermarket shoppers with information about the nutritional balance of the food in their shopping trolley. It addressed the limitations of the previous experiment in the following ways: first, it was a longitudinal study, with a month of recording participants' baseline shopping data followed by a month of participants using the device while doing their weekly shop; second, shoppers could use the app to get nutritional information about *all* the food products in a supermarket, not just the items specified by experimenters; third, by developing a mobile app we demonstrated that shoppers can run the program on their own mobile devices and more widespread future use will not require the support of a supermarket.

Figure 6: A supermarket shopper scanning a product using the Lambent Shopping Trolley.

Healthy Shopping App Design

The app is designed for single people doing a weekly shop. It displays a plate representation of the proportion of the four main food types in a balanced diet (Figure 8). We calculated the weekly amounts of

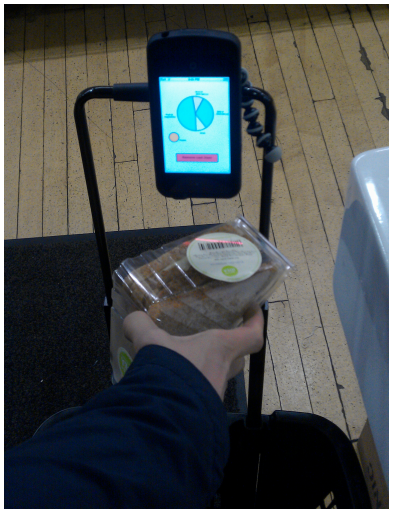

Figure 7: A supermarket shopper scanning a product using the *Healthy Shopping* app. The longitudinal study loaded the app on an iPhone Touch connected to a Linea Pro 2D barcode scanner. The mobile device is connected to the trolley handle so that participants had both hands free.

fruit and vegetables, meat and alternatives, milk and alternatives and grains by averaging the mass for each food type recommended by the US, Canadian and UK governments. After consultation with a focus group, we named the category containing high fat and sugar items 'treats' and on the advice of nutritionist set the recommended amount as 210g per week. In the study the app was loaded on an iPod Touch and participants scanned food items using a connected Linea Pro barcode scanner (Figure 7). The food type and mass of the scanned item was fetched from an online database of just over 3000 products. The visualization updates in real-time to show what proportion of the weekly food type allowance has been purchased, visualizing this by changing the size of a darker segment within the corresponding pie segment. For example, in Figure 8 just over half the week's fruit and vegetable allowance has been purchased but only around 15% of milk and alternatives. When a shopper has almost purchased the whole weekly allowance of a food type, the edge of the associated pie segment goes red, except for fruit and vegetables which has no upper limit. The allowances act as social norms which can potentially influence shoppers' behaviour. If a shopper decides not to purchase a product having scanned it and seen its nutritional value then they can touch the 'Remove Last Item' button and the visualization updates.

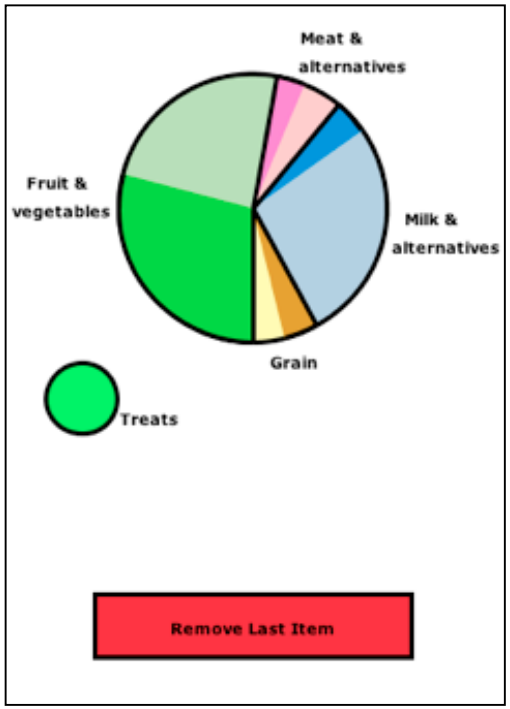

Figure 8: The Healthy Shopping app visualization consists of a plate representation of the relative proportions of the four main food types in a balanced diet. There is also a small 'treat' circle that goes red once the recommended amount of high fat and high sugar foods have been selected.

Study Design

Seven participants were recruited: five professionals and two students, ranging in age form 24 – 31. All of the participants met the following criteria: first, they were free to participate in all 8 weeks of the study; second, they lived alone and generally consumed their meals at home; and third, they did the majority of their shopping during a weekly visit to a supermarket.

The study took place in Planet Organic, a medium sized supermarket that caters for health conscious shoppers. Each participant conducted their weekly shop alone but was shadowed by a researcher. The number of items

purchased, the duration of the shopping trip and the amount of money spent was recorded. For the first four weeks, participants did not use the app and we kept their shopping receipts to determine how much of each food type they purchased. For the last four weeks of the study, these data were stored in an online database by the app.

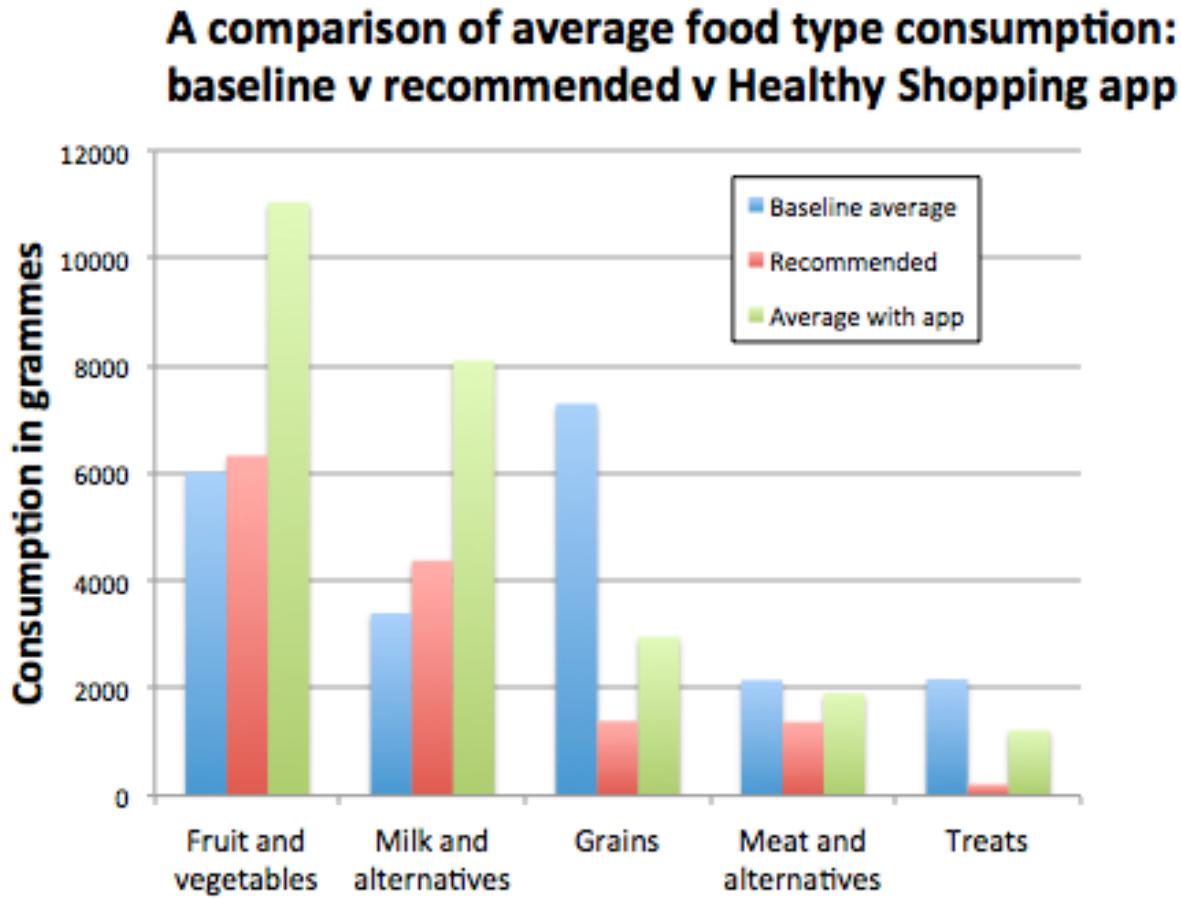

Figure 9: The recommended consumption (grammes) of the different food types compared with the average amount of each category purchased during the baseline period and when using the Healthy Shopping app.

Results

The initial four weeks of baseline data demonstrated that overall none of the participants had a balanced diet (defined as within 15% of the recommended amounts for all of the food types). On average they were balanced for fruit and vegetables, but under purchased milk and alternatives and over purchased grains, meat and alternatives and treats. 4/7 of the participants recognised that they did not have a balanced diet but 3/7 did think their diet was balanced, even though that was not the case.

After using the Healthy Shopping app for four weeks, there were significant changes in two of the food categories (Figure 9). First, participants purchased more milk and alternatives, moving from under to over purchasing the recommended amount (paired t-test(3) = -4.968, $p < 0.05$). Second, they purchased less grains and moved towards the recommended amount (paired t-test(3) = 8.643, p , 0.01). The amount of fruit and vegetables purchased almost doubled and was considerably more than the recommended amount. Although not significant, on average the amount of meat and alternatives and treats reduced and moved towards the recommended level. However, overall none of the participants had a balanced diet at the end of the study. Half of the participants thought that the Healthy Shopping app had affected their shopping behaviour.

Limitations and Future Work

We assumed that participants did a weekly shop for themselves and that they mainly cooked their meals at home, rather than going out for food. Questionnaires indicated that on average the participants went out twice a week for food, meaning that their diet consisted of other food besides what they purchased at the supermarket. However, although not a perfect mapping, we think that the Healthy Shopping app provides a good idea of the balance of participants' diets. In future studies we will enable participants to use the app to record food they eat out, as well as food they purchase at supermarkets.

The small number of participants was a limitation of the study and we aim to recruit larger numbers in future studies.

The barcode scanning was done with a dedicated peripheral hardware device (Linea Pro) attached to the iPod Touch. These are relatively expensive (£350) and a limitation on the widespread use of the app. Fortunately, there have been significant improvements in the speed and usability of optical scanning using the devices' built-in camera. Future iterations of the Healthy Shopping app will therefore not require any extra hardware.

Thanks to the support of Planet Organic in providing their product database, participants were able to see nutritional information on all the grocery items in that supermarket. However, it is a small supermarket chain that primarily caters for people who are interested in buying ethical-sourced and healthy food. It is not the type of supermarket where most people would generally do their weekly shop. In order to demonstrate the viability of the Healthy Shopping app in more mainstream supermarkets we need to have access to larger product information databases and we are currently exploring how these can be created using a crowd sourcing approach.

Summary

A longitudinal study has demonstrated that a simple real-time visualization of the nutritional balance of a shopping trolley can lead to significant changes in participants' shopping habits and an improvement in their diets. Mobile devices can provide people with nutritional information when they are deciding what food to purchase in a supermarket. In this context, appropriately presented health information can have a significant influence on what people buy and therefore what they eat. We believe this is a promising approach to addressing a global health issue and we are exploring its potential further in ongoing research.

Acknowledgements

We thank all the study participants and Planet Organic for letting us use their product database and allowing us carry out the study in their supermarket.

References

[1] Cohen, I., Ghane, V., May, E., Mayes, J. and Edgar, S. E. (1996) Some College-age Students are Unable to Use the Food Guide Pyramid without Instruction. *Journal of the American Dietetic Association,* 96(9), A102.

[2] Cowburn, G. and Stockley, L. (2005) Consumer Understanding and Use of Nutrition Labelling: A Systematic Review. *Public Health Nutrition*, 8(1), 21-28.

[3] Flegal, K.M., Carroll, M.D., Ogden, C. L. and Johnson, C. L. (2002) Prevalence and Trends in Obesity Among US Adults, 1999-2000. *Journal of the American Medical Association*. 288(14), 1723-1727.

[4] Heath, C. and Heath, D. (2010) *Switch: How to Change Things When Change is Hard*. Random House: London.

[5] Kalnikaitė, V., Rogers, Y., Bird, J., Villar, N., Bachour, K., Payne, S., (2011) *Proceedings of the 13th International Conference on Ubiquitous computing,* 11-20.

[6] Kalnikaitė, V., Bird, J. and Rogers, Y. (2012) Decision-making in the Aisles: Informing, Overwhelming or Nudging Supermarket Shoppers? *Personal and Ubiquitous Computing*, 1-13.

[7] Krauss, R. M., Eckel, R. H., Howard, B., Appel, L. J., Daniels, S. R., Deckelbaum ,R. J., Erdman, J. W. (2000). AHA Dietary Guidelines – Revision 2000: A Statement for Healthcare Professionals from the Nutrition Committee of the American Heart Association. *Circulation*, 102(18), 2284-2299.

[8] Noland, C. and Merelles, M. I. (2008) Visual Representation of Health Information: A Critique of the 2005 Food Pyramid. *American Communication Journal*, 10.Boehm, G. Ambient Persuasive Guidance (2011). *Proceedings of TEI 2011,* 431-432.

[9] Wansink, B. and van Ittersum, K. (2007) Portion Size Me: Downsizing Our Consumption Norms. *Journal of the American Dietetic Association* 107,1103–1106.