

**Nudging the trolley in the supermarket:
How to deliver the right information to shoppers**

Peter M. Todd *

Indiana University, Bloomington, USA

pmtodd@indiana.edu

Yvonne Rogers

The Open University, Milton Keynes, UK

y.rogers@open.ac.uk

Stephen J. Payne

University of Bath, UK

s.j.payne@bath.ac.uk

* Corresponding author

Abstract

The amount of information available to help decide what foods to buy and eat is increasing rapidly with the advent of concerns about, and data on, health impacts, environmental effects, and economic consequences. But this glut of information can be distracting or overwhelming when presented within the context of a high time-pressure, low involvement activity such as supermarket shopping. How can we nudge people's food shopping behavior in desired directions through targeted delivery of appropriate information? We are investigating whether augmented reality can deliver relevant 'instant information', that can be interpreted and acted upon *in situ*, enabling people to make more informed choices. The challenge is to balance the need to simplify and streamline the information presented with the need to provide enough information that shoppers can adjust their behavior toward meeting their goals. In this paper we discuss some of the challenges involved in designing such information displays and indicate some possible ways to meet those challenges.

Categories and Subject Descriptors

H.5.2 [User Interfaces]: Evaluation/methodology.

General Terms

Design, Experimentation, Human Factors.

Keywords

Food information displays, supermarket shopping, ambient information interfaces, simple heuristics

Introduction

Increasingly we are told about the risks, costs, and benefits of particular food choices. A flood of information is becoming available from a variety of sources, online, on food labels, in information leaflets and books, aimed at informing the consumer so that better decisions can be made while shopping. But all this information risks overwhelming and overloading the shopper trying to navigate the complex store environment in a hurry, leading to the opposite outcome: poor decisions made without the proper input. How can all this information be consolidated, pruned, and presented to supermarket shoppers in an easy to understand and meaningful form that will actually help them make better choices in terms of the values they care about?

Technology pundits and researchers are beginning to promote ‘augmented reality’ that uses Smartphones and other ubiquitous technologies as the latest solution to this problem. Kuang (2009), for example, marvels at the possibility: “What if all the food in your grocery store was marked with a QR code—you could compare the carbon footprints of two batches of produce... without having to spend any time or effort looking it up...” He continues by claiming it is “The best chance we have to speed crucial information about our world to the people living in it”. This vision, however, begs the research questions: Will people be able to read and act upon such ‘instant information’? Will just throwing more information at people have the desired galvanizing effect of encouraging and empowering people to act upon various social causes (e.g., reducing carbon emissions) or improve their well-being (e.g., changing their diet)? Or do we need to tailor that information glut into simple nudges that make behavior change easy to achieve? And if so, what kind of nudges will work?

Having instant information at one’s fingertips is certainly a promising technological approach, but for it to succeed in changing people’s behavior we need to understand how new forms of augmented reality are interpreted and used, especially when *in situ*. While the capabilities of the emerging

technologies are impressive in how they can project contextualised information, there is a paucity of research into whether people can process and exploit that extra information profitably. It is easy to imagine soda drinkers enjoying the surprise of being presented with a new branded game or a funny website on their mobile phone, but it is less clear whether people will make greener and healthier choices while keeping to their weekly budget when presented with extra information of one form or another in the middle of their busy shopping trip. Thus, research is needed, first, to determine whether instant information will enable people to make better-informed choices when shopping, and second, to ascertain whether and how such information is able to change people's behavior in the longer term.

Technology for ubiquitous information delivery must balance giving people enough new information to improve their decisions against overwhelming them with new things to consider. Ambient information displays, as already used in homes and offices to provide feedback about energy consumption and nudge users toward greater conservation, may strike the right balance in food purchase and consumption as well—for instance, lighting up a shopping trolley (cart) handle in a color representing the fat content of the products a consumer has chosen so far. However, as we discuss in this paper, moving beyond momentary nudges toward long-term behavior change requires providing detailed-enough feedback to enable learning what to do in the future, for instance on the next shopping trip. We argue that we must improve our (currently limited) understanding of whether and how people attend to and learn from visualizations of multi-dimensional information while engaged in an ongoing activity such as food shopping. This can be done using cognitive science models of decision-making and learning together with design principles for information visualization and interaction design.

Background

Research on Decision Making Strategies

Technology designed to deliver an ever-increasing amount of information to consumers is intended to help them make better decisions or otherwise influence their behavior. But without knowing how people actually process the information they are presented with in service of decisions and actions, we cannot say how to help decision makers make better decisions, nor what and how much information would best accomplish this goal. While it is obvious that we must take human psychology into account in figuring out what and how to communicate to consumers, we first have to settle on an appropriate view of that psychology, which means adopting one of a number of competing views of human rationality.

The traditional view of unbounded rationality says that decisions should be made by gathering and processing all available information, without concern for the human mind's computational speed or power. According to this view, found surprisingly commonly in the fields of economics, psychology, and consumer behavior, information technologies should either shower people with all the information that could possibly be relevant for making a particular decision and let the consumer work out the optimal inference for themselves, or the technology should gather as much information as possible and then make the decision for the consumer by weighing and adding it all into a final recommended choice. This view of unbounded rationality at work can be seen in various decision aid sites on the Web, such as selectsmart.com, which helps users make choices about everything from what kind of beer to purchase to what kind of pet to buy, by gathering extensive data on dozens of questions about the user's preferences and the strength of each preference, and then processing all that information into a final ordered list of possibilities for the user to buy. This information-intensive approach to choice does not match how most people make decisions most of the time, particularly in settings with high time pressure and relatively low consequence such as food shopping; as a consequence, traditional views of rationality

provide a poor basis not only for building psychological models of choice, but also for creating decision tools meant to be used or understood by real people (Katsikopoulos & Fasolo, 2006).

In contrast, the perspective of *bounded rationality* studies how people (and other animals) can make reasonable decisions given the constraints that they naturally and commonly face, such as limited time, information, and computational abilities. Instead of needing to process all the available information and consider all the options, people can often make surprisingly good decisions using simple “fast and frugal” heuristics, which are rules of thumb or short-cut choice strategies that ignore most of the available information. The trick is to ignore the unnecessary pieces of information, and just search for the few pieces of information that will be most useful, or the few most appropriate options, and process them appropriately. Herbert Simon championed this view of cognition, arguing that because of the mind’s limitations, humans “must use approximate methods to handle most tasks” (Simon, 1990, p. 6). These methods include recognition heuristics that largely eliminate the need for information and just make choices on the basis of what is recognized (Goldstein & Gigerenzer, 2002), search heuristics that look for options only until one is found that is “good enough” (Todd & Miller, 1999), and choice heuristics that seek as little information as possible to determine which option should be selected (Payne, Bettman, & Johnson, 1993; Gigerenzer, Todd, & the ABC Research Group, 1999).

Simon’s notion of bounded rationality, originally developed in the 1950s, had great influence on psychologists and economists who followed, in two distinct ways. Both camps agreed that the mind is limited in what it can accomplish and what information it will use. But one set of researchers argued at the same time that the decisions people make are often flawed as a consequence: We would, and should, all be unboundedly rational, if only we could. Under this view, the simple heuristics that we so often use can often lead us astray, making us reach biased decisions, commit fallacies of reason, and suffer from cognitive illusions. The very successful “heuristics-and-biases” research program of

Tversky and Kahneman (Kahneman, Slovic, & Tversky, 1982) has followed this interpretation of bounded rationality and led to much work on how to “debias” people so they could overcome their erroneous heuristic decision making.

In stark contrast, a second set of researchers has found that people can and often do make good decisions with simple rules or heuristics that use little information and process it in quick ways (Payne, Bettmann, & Johnson, 1993; Gigerenzer et al., 1999; Gigerenzer & Selten, 2001). This second view of bounded rationality argues that our cognitive limits do not stand in the way of adaptive decision making; in fact, these bounds can even be beneficial in various ways (Hertwig & Todd, 2003), because the mind is adapted so that its bounds often match the structures of information available in the environment. This leads to a new conception of bounded rationality, termed *ecological rationality*, that emphasizes the importance of the environmental information structures and how they fit to mental decision structures (Todd, Gigerenzer, & the ABC Research Group, in press; Todd & Gigerenzer, 2007). The implication of this perspective for information display systems is that if people typically use fast and frugal heuristics to process only a few pieces of information when making decisions, then striving to deliver them greater and greater amounts of information may not achieve the desired end of aiding good decisions—or at least not as cheaply and effectively as could otherwise be possible. Thus this view of bounded and ecological rationality indicates that we should figure out what information people will actually use and focus on delivering just those items—a less-is-more, simplicity-based approach that is appearing in applications in business and marketing (Fasolo, McClelland, & Todd, 2007), medical communication (Todd et al., in press), and elsewhere. This is akin to structuring the information environment in subtly different ways that can easily and even unconsciously influence people’s choices and behaviors in desired directions, achieving “informational nudges” (cf. Thaler & Sunstein, 2008).

In line with bounded rationality, people often rely on a single reason to make decisions, choosing an option because just one thing about it leads them to select it over other options. This approach can be quick and simple, avoiding the need to make trade-offs between multiple, possibly conflicting, attributes for different options (e.g., if option A is cheaper, but option B will last longer, making the decision solely on the basis of price and ignoring longevity, or vice-versa, means that no trade-off need be made between the two). But can such a heuristic approach ever be reasonable? To find out, we must first define specific models of heuristics that use a single reason, and then compare them with traditional approaches using several pieces of information, both applied to decisions in different types of environments to see where each can work best.

A standard rational decision making approach is to weigh all the available information about each option by how important it is for the choice to be made, and then add all those weighted factors together to arrive at a total value for each option, and finally to choose the option with the greatest summed value. In contrast, a well-studied “fast and frugal” heuristic that relies on the principle of one-reason decision making is the take-the-best heuristic (Gigerenzer et al., 1999). Take-the-best and other one-reason decision heuristics are frugal in that they do not look for any more information than they need to make an inference, and they are fast because they do not involve any complex computation—not even the multiplication and addition required by weighted additive mechanisms. In comparisons with weighted additive models, take-the-best has been found to work well in particular types of environments, and not in others (Todd et al., in press). Specifically, take-the-best is not ecologically rational compared to weighted additive mechanisms in environments where the available pieces of information are roughly equally useful. But many environments, including that of consumer choice, are characterized instead by a distribution of information usefulness that is highly skewed or “J-shaped” (i.e., falling off rapidly, so that the most useful piece of information is considerably more important than

the second-most useful piece, which is considerably more important than the third, etc.). In such environments, take-the-best can outperform the traditionally rational weighted additive model, particularly when generalizing to somewhat new situations (Gigerenzer et al., 1999).

Thus, empirical observations of actual quick and simple decision making, along with theoretical arguments that human minds have evolved to act quickly and make ‘good enough’ decisions by using fast and frugal heuristics, support the contention that humans typically ignore most of the available information and make choices using only a few important cues. In the supermarket, this can be seen as shoppers make snap judgments based on a paucity of information, such as buying brands they recognize, are low-priced, or have attractive packaging, seldom reading other package information (Todd, 2007). But at the same time, recent consumer surveys reveal that shoppers are demanding more information about the products they buy and are becoming increasingly aware of the global consequences of the decisions they make (EDS IDG, 2007). This raises the question of whether it is possible to encourage shoppers to pay attention to new (and possibly more) types of information, such as nutritional, ethical, and environmental aspects, when making their food purchases and subsequently deciding how to use what they have bought to make healthy meals that have a low carbon footprint.

Research on Information Visualization

Despite the literature reviewed above, there is a scarcity of research on how people use multi-dimensional information under time pressure and the extent to which it affects rapid decision making (Feunekes et al., 2008). Visualization research has tended to adopt an unbounded rationality perspective, assuming that people have the time and cognitive capacity to pull out and use whatever information the displays provide. Within the field of Information Visualization there have been a number of tools that have been developed specifically to represent multidimensional data that allow for comparisons (Card,

Mackinlay, & Shneiderman, 1999). Other simple canonical forms such as tables and trend graphs have been developed for web-based decision-making activities, including online shopping, making investments, choosing insurance policies or buying a house. An innovative approach has been to develop interactive visualizations that show some aspects of the performance of objects for a range of different parameter values. An early example was the Influence Explorer (Tweedie, Spence, Williams, & Bhogal, 1994) that allowed a user to compare how products (e.g., different light bulbs) perform on core values (e.g., brightness and working life) when varying multiple parameters (e.g., diameter, length, material and number of coils). More recently, bargrams have been developed for e-commerce applications. For example, EZChooser helps consumers choose one item from many (e.g., cars) through selecting attributes that are visualized as parallel horizontal interactive histograms along a number of dimensions (Wittenburg, Lanning, Heinrichs, & Stanton, 2001). But even though these kinds of visualizations are mostly targeted at non-expert users, they are essentially visual query languages that require considerable cognitive effort to interpret.

A different approach to visualizing information has been to create ambient displays that represent invisible dynamic processes, such as changes in weather, stock, currency, and the amount of human presence or activity in a building. The idea is that people need only to glance at them when walking past to glean the current state. Types of ambient displays that have been used include lights that glow in intensity (e.g. Hello.Wall—Prante et al., 2003), water that ripples (e.g. ambientROOM—Wisneski et al., 1998), water fountains that vary in height (e.g. Datafountain—van Mensvoort, 2005), and bottles or other objects that jiggle (e.g. ambientROOM—Ishii et al., 1998). Part of their appeal lies in how they make the invisible visible through being aesthetic, public, fun, informative, and compelling. Their *glanceability* is also considered key; just as clocks on a wall are momentarily looked at, these

displays, too, are intended to be glanced at occasionally and peripherally without distracting people from their ongoing activities.

More recently, ambient displays have been designed to do more than inform; by depicting certain kinds of information that can influence people's behavior. An example is a sculpture that sits near a person's computer monitor and slumps over if that person continues to sit without taking a break (Jafarinami, Forlizzi, Hurst, & Zimmerman, 2005). After the person takes a break, the sculpture sits upright and is assumed to be healthy. The way this kind of ambient display is assumed to influence is by raising people's awareness of a particular behavior that they normally overlook or try not to think about.

More extensively, Rogers et al. (2010) investigated whether a community's behavior could be changed by situating various forms of ambient displays in their workplace. The aim was to influence the prevalence of a socially desired behavior, namely, taking the stairs when moving between floors. A combination of abstract lures and aggregate representations was designed to entice and reveal stair/elevator usage for different time periods. The abstract lure display comprised white LED lights that were embedded in a carpet near the stairwell and elevator. Whenever someone approached them they started to twinkle, forming an aesthetically pleasing flowing pattern that suggested organic spread toward the entrance of the stairwell. The aggregate representation was designed as a large installation that was hung in the atrium of the building. Two moving 'clouds' of spheres were used to depict the aggregate number of people taking the stairs and the elevator over time. The information provided by both displays was intended to inform in subtle and playful ways, and in doing so nudge people to change their behavior. A two-month in situ study showed that the two displays elicited much intrigue and discussion from both the inhabitants of and visitors to the building. Moreover, although few people admitted to changing their behavior in response to seeing the displays, logged data of people's actual movements showed a statistically significant increase in the proportion of stair usage after installation.

The findings suggest that the ambient displays had the effect of increasing awareness about stairs and elevators that, in turn, may have unconsciously nudged some people to take the stairs at *choice moments*, which they may subsequently not have remembered. Choice moments are the times when people might have previously taken the elevator, because they were feeling lazy or tired, and where they switched to taking the stairs without necessarily being aware of doing so.

In contrast to these implicit ambient nudges, a number of persuasive technologies have been developed that explicitly encourage people to take more exercise or reduce energy consumption. Examples of representations intended to motivate people to exercise more include Fish'n'Steps (Lin et al., 2006), Chick Clique (Toscos, Faber, An & Gandhi, 2006), and UbiFit (Consolvo et al., 2008), where various types of graphic representations (e.g., butterflies, flowers, bar charts) are used to represent amount of exercise-type performed (e.g., cardio, strength training, and walking). Findings from a three-month field trial of UbiFit showed that these display systems can be motivating, encouraging participants to maintain fitness levels that were significantly higher than for a control group without the representations (Consolvo, McDonald, & Landay, 2009)

Another approach is to design representations that show the average usage of some resource and the extent to which people deviate from it, with the aim of helping people to alter their resource use to be closer to or better than that average. For example, an energy monitor/display that is commercially available in many countries, called Wattson, shows both the watts or cost of how much electricity someone is using in their home at a given time and how this compares with their own average over time. The former is conveyed using LEDs on the topside, while the latter is shown via a colored light from the underside which glows blue when the householder is using less energy than normal, purple when use is average, and red when use is higher than usual. The idea is that on seeing red people will start to turn off lights and appliances to change the display back to purple or even blue.

Most dramatically, Shultz et al. (2007) have shown how emoticons can have a powerful effect on changing energy consumption behavior. In the first part of their study, a number of householders were told exactly how much energy they had used and the average consumption of energy by others in their neighborhood. The above-average energy users then significantly decreased their energy use while the below-average energy users significantly increased theirs (presumably because they felt they had more room to increase their consumption). But then the researchers tested the effect of additionally giving householders who consumed more energy than average an unhappy smiley icon—suggesting it was socially disapproved—and those who consumed less than the norm a happy smiley icon—suggesting their energy consumption was socially approved. The impact of providing these two representations was dramatic: The big energy users showed an even *larger* decrease in their energy use than in the first condition, while the below-average users did not change their energy consumption upward (presumably because the addition of the happy emoticon suggested the socially positive aspect of their behaviour).

These studies suggest that there are benefits of using different kinds of representations and ambient displays to encourage people to change or adhere to certain kinds of desired behaviors, such as taking the stairs, taking more physical exercise or reducing energy consumption. Here, we are interested in how best to design representations for different decision-making activities. In the following sections, we first consider how best to present information that can be glanced at and perceived rapidly to guide supermarket shopping decisions *in situ*. In particular, how can we help people make informed decisions when confronted with many possible options, such as 50 different kinds of yoghurt to select from? Second, we consider how to design aggregate displays of cumulative information that is not otherwise available in the store, such as a summary of the total fat content of products placed in a shopping trolley relative to some desired norm. Third, we consider what kind of information visualizations can support

collaborative planning activities, such as a family deciding together how to make a healthy meal with a low carbon footprint.

Displaying Informational Nudges

We propose that rather than providing ever more information to enable consumers to compare products in minute detail when making a choice, a better strategy is to design technological interventions that provide just *enough* information and in the *right* form to facilitate good choices. One solution is to exploit new forms of augmented reality technology that enable ‘information-frugal’ decision making, in the context of an intensive activity replete with distractions (i.e., shopping in a supermarket or deciding at the kitchen table what to have for dinner).

An important consideration when representing multiple dimensions that can be glanced at and perceived rapidly is to enable comparisons to be made and cumulative information inferred *in situ*. For example, simple contrasting icons (e.g., thermometer icons, percentage bars, balls that change in color) can be presented which increase or decrease on some dimension in relation to the values being represented. An instance of such a display approach is the GoodGuide iPhone app that rates products using a scale from 1-10 together with colored icons to represent where the products fall on the dimensions of health, environment and society. A score of 10 represents the best performance while a score of 0 the worst, based on a number of indicators they have developed. The icons can be viewed at a glance and can be listed in order of highest rated products or expanded to provide more detail for individual products (see Figure 1).

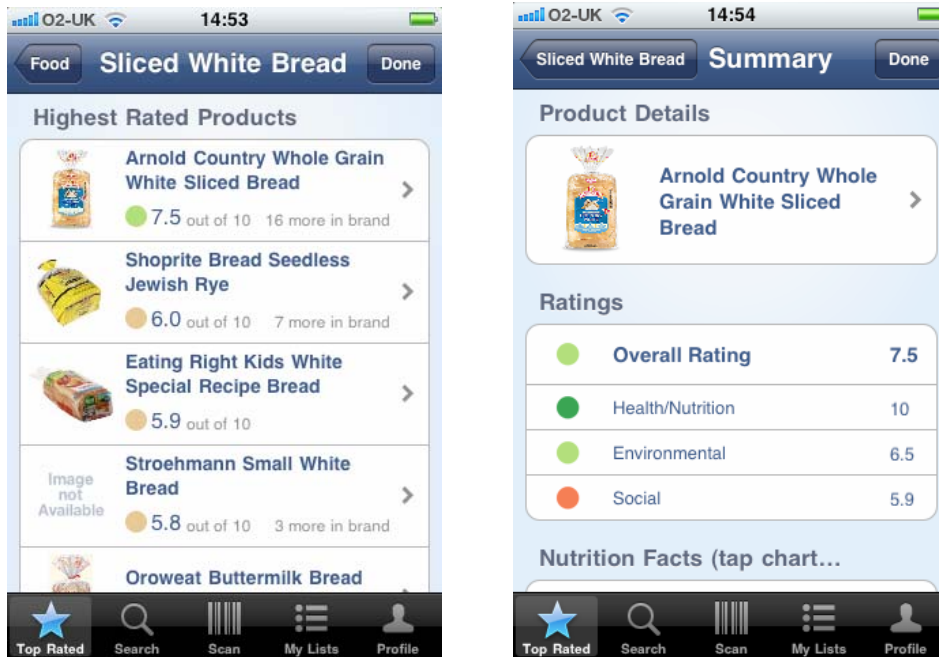
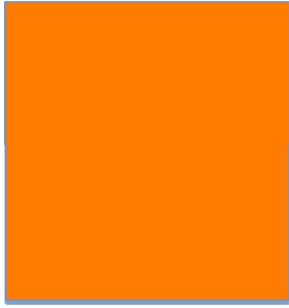


Figure 1: GoodGuide display using numbers and colored icons to represent overall rating and other dimensions for a category of product (e.g., sliced whitebread) and a single item in that category (e.g., Arnold Country Whole Grain). The ratings are scored out of 10 and displayed besides an emerald green icon when most ‘beneficial’, brown-orange when ‘controversial’ and red when ‘concerning’.

Another approach is to fuse relative measures on different dimensions (e.g., greenness, price, fat level) into singular displays where shape carries the salient information, such as a rectangle that gets wider to convey price and taller to convey a nutritional dimension that is general (healthiness) or specific (e.g., salt content) (see Figure 2). A third dimension, such as ‘greenness’, could be added by filling in the rectangle with a shade from red to green to show the quantity of carbon emissions for that product. Similar to the idea behind Chernoff faces, the visualizations will be placed side by side to enable quick comparisons.



Product A



Product B

Figure 2: An example of a fused visualization for multi-dimensional data where nutrition is represented by height and its carbon footprint by width. In this example product A is ‘good’ (the rectangle is taller than its width) whereas product B is ‘bad’ (it is wider than its height).

Another important question is whether emotive visualizations can be designed to persuade people to select food items they might not otherwise choose. For example, will smilies—indicating approval—placed on products that pass a ‘greenness’ standard encourage people to buy them more than products that do not bear the smiling label, even if the former are more expensive? Is color-coding, such as the traffic light labeling promoted by the Food Standards Agency in the UK, emotive?

Design Considerations for an In-store Trolley Interface

What then is a good way to provide appropriate information quickly and simply to shoppers in order to aid their decision-making during the hectic, distracting setting of a trip to the supermarket? Here we assume the shoppers have selected a particular dimension that they care about and want to be more responsive to in terms of their buying behavior—for instance, choosing products that are lower fat,

or more sustainably grown. To inform shoppers about how they are doing in achieving this particular goal during their shopping expedition, cumulative values of the dimensions of interest across all products chosen so far could be summed up and displayed in an ambient manner as the current ongoing overall score “projected” onto the handle of the shopping trolley as a color. For example, a green handle could signify that the shopper has obtained a ‘carbon footprint’ or ‘fat content’ score below their target (or below some population average), while a red handle would indicate that the trolley’s contents are above the desired level, with intermediate levels indicated by intermediate colors (see Figure 3). This simple core idea allows a range of possibilities, with likely advantages and disadvantages; in particular there is an important issue in terms of which summary statistics of a trolley's contents that might most helpfully be displayed.



Figure 3: Two hypothetical shopping trolleys with (a) red and (b) green glowing handles, indicating aggregate ‘healthiness’ of products selected relative to the average for a weekly shop for a family of four.

Cumulative versus running average displays. A cumulative display might, for example, use the color of the trolley's handle to indicate the total value of the contents on the dimension of interest. For example, a green handle could signify that a shopper has obtained a 'carbon footprint' or 'fat content' score below some target (or below some population average), provided the goal has been given in terms of total number of grams or whatever else is being measured. In contrast, a red handle would indicate that the trolley's contents are above the desired level. Depending on display technology, it may be possible to represent intermediate levels by intermediate colors.

Such a cumulative display is in accord with our low-information nudge principle, but has several limitations. First, assuming N colors can be displayed (and perceived by users), the trolley will pass through at most $N-1$ state changes during the shop as it accumulates the growing total value of what has been selected. In the extreme case, a successful shop may be indicated by no display changes, for instance when the empty trolley contents start out 'green' (below the maximum level for e.g. fat) and stays 'green' because the maximum level is never reached. The display uses a substitutive dimension to display an underlying additive scale, meaning changes will not be continuous and may be difficult to attribute to particular items. Second, the very nature of a cumulative property means that the display will be correlated with the simple amount of stuff in the trolley. This becomes a salient issue when one considers that different shoppers may have various goals for a single shop—for instance, they may be shopping for one person for a few days, or for several people for a week or more. If cumulative displays are to be used, issues of normalization must be addressed.

The second type of simple trolley display would show a running average of the items, as they are placed in the trolley. Once the idea of by-item properties is considered it becomes possible to normalise the dimension-of-interest by correcting for item properties (e.g. number of portions). So a simple display of this nature might show, say, a running average of 'fat content per person-meal'. Clearly, such

a running-average display will be meaningful independent of the total contents of the trolley, and may vary continuously, in both directions, during the shop, as items are added to the trolley and the running average rises and falls. This may make it more compelling and more informative for users without increasing its intrinsic complexity.

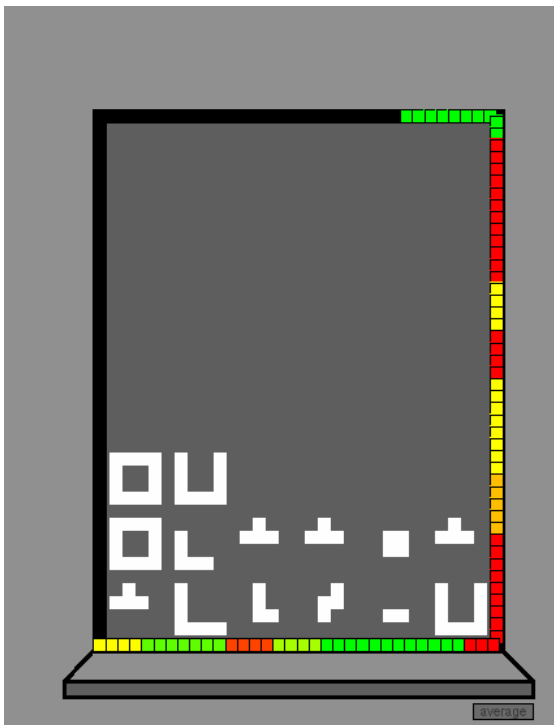


Figure 4: A simulation of a shopping trolley with LEDs that light up depending on the size of each product placed in it and the dimension chosen by the shopper (e.g. fat content per person-meal); green is below the average on that dimension, yellow-orange is average and red is above the average. The white pieces in the shopping trolley represent products and are moved into the trolley (simulating a purchase decision) from an adjacent palette where the size is known but the fat content unknown until scanned. The average for all items in the trolley can be compared against some norm, such as the average for a weekly shop for a family of four, can be displayed by pressing a button on the handle.

A possible disadvantage of a simple running-average display is that it seems to explicitly encourage the kind of rebound or boomerang behavior noted by Schulz et al. (2007) and others: Whenever the display indicates an unsatisfactory running average, it can be 'improved' by the addition of a 'good' item. However, this may be desirable. What is less desirable is if the boomerang flies in the opposite direction, as for instance when a shopper has achieved a 'green' display by purchasing many healthy items and decides to have a reward of a tub of ice cream, which still does not drive the display into the red zone.

Fusing cumulative total and running average displays. With certain display designs it is possible to simultaneously reflect running average and cumulative total, perhaps sidestepping the disadvantages of each. Imagine a display made up of many simple components—for example, a row of lights along the handle and edges of the shopping trolley—each of which can change in some property, such as color (see Figure 4). When an item is added to the trolley, a new light could be illuminated (or several lights, e.g., one per serving) with a color that reflects that item's properties. Now the total quantity of red or 'redness' indicates (to some approximation) the cumulative total of the shop (at least in terms of its overall quality), whereas the proportion of red to green indicates the running average. The simple number of illuminated lights—for instance as indicated by the length of the illuminated strip along the handle—would indicate the overall size of the shop-so-far. Alternatively, it would be possible to have a separate indication of the cumulative total of the property of interest—a larger single light that changes color, say—so that the total on that dimension could be displayed more clearly. This cumulative total display could also be set up to come on only when the shopper explicitly requests it, as for instance

activating the button shown in Figure 4; the idea here is to give the shopper the chance to have a private peek at how well they are doing rather than displaying this continuously for other shoppers to see.

The fused display has advantages in terms of the issues raised above. It changes with every item, but not in a way that encourages rebound effects. It is meaningful at all stages of the shopping trip, and independently of the intended size of the shop. With colleagues we are currently exploring such fused displays in laboratory and in-situ experiments.

Such an ambient and publicly visible display must first be studied to see if it fits with how people want to shop, or engenders unexpected side-effects. Will people be more or less likely to change their behavior when information about the contents of their shopping trolley is publicly visible for all to see rather than being privately displayed? Would shoppers try to fill their trolley with healthy and green foods and on finding they were under the average then treat themselves to luxury goods high in fat and food miles? Would having their shopping trolley glow green at the check-out, indicating the contents were well below the average, make them feel good in front of other shoppers (Shultz et al, 2007)? Would the prospect of others seeing just how much butter and cheese they are buying make shoppers think about buying less, or just thinking about shopping elsewhere?

Other Tools to Promote Learning about Shopping

Assuming such an ambient information display *Cumulative Tool* achieves the desired features of providing some feedback without overloading the decision maker, without undesired effects of scaring shoppers off or making them “boomerang” and offset their good behavior with poorer choices, the question remains whether this kind of simple display provides *enough* feedback to allow the shopper to adjust behavior in the desired direction, e.g. reduced sodium or enhanced greenness. Seeing that one’s

entire trolley is red-lining above the goal level may motivate behavior, but it does not directly indicate what to do to bring the level back down. Thus, we must develop and test methods for ensuring that the (minimal) information delivered is actually actionable and conducive to behavior change.

There are at least three approaches that can be taken to solving this problem, which is essentially one of allocating global feedback appropriately to individual choices of products (akin to the “credit assignment” problem in machine learning). First, we could leave it all up to the users, and assume (or hope) that when they end their shop with a “green” trolley, they will buy more things like those the next time around, and when they get a “red” trolley, they will buy different things next time. This leverages the human shopper’s intelligent ability to learn from diffuse reinforcement over time, but it will probably be slow, requiring many shopping outings before reliable change occurs. Second, to speed up this process, we could provide more specific feedback about each product that goes into the trolley, for instance momentarily flashing the ambient display with a color corresponding to the box of sugar-frosted chocolate bombs or bag of figs being chosen. This will allow shoppers to make more targeted decisions about each product, provided they remember that individual feedback.

Third, to remove the need for such memory, a further interface can be developed to let shoppers query how they should adjust their purchases to come closer to their goal. This could take two main forms. A *Comparative Tool* could run as a ‘private’ mobile application on a smartphone or PDA and be displayed on the device or somewhere in the environment, such as the shopper’s hand or the product package itself. After identifying the product via a photo or code scanner, the tool will show the product values on the dimensions of interest, and indicate whether this product helps or hinders the achievement of the current shopping goal. This interface could also be used in a comparative manner, scanning two or more products while they are still on the shelf and then showing at a glance which product is best based on the selected dimensions.

As a second ‘off-line’ method of providing more explicit feedback, a *Collaborative Tool* running on a home computer or surface display would allow shoppers to find out further information about the products they have bought once they get them home, along with input from their families. Multiple users could reflect and discuss together the decisions behind their food purchases with a view to attaining their goals at their next weekly shop, exploiting collaborative planning and social pressures that take place in a family setting. An interactive planner application would enable family members to find out more about particular dimensions (e.g., nutritional values) on a product, meal, or weekly-shop basis, and provide recipe-specific visualizations enabling items to be swapped. For example, a suggestion by dad to cook coq-au-vin for dinner will show it is low on ‘greenness’ (because of a large carbon footprint). This is a dimension the son has selected as an informational layer. Alternative items can be swapped with the chicken, such as tofu, which may then be shown by the application to have a higher greenness value (i.e., smaller carbon footprint). Finally, specific shopping lists could be generated that would achieve the goals set by the shopper and others involved.

Further Directions

To test whether any of these approaches succeeds in nudging shoppers’ behavior in specific directions within a reasonable time-span, we have planned both lab-based experiments and field studies. One line of investigation will assess how the different information displays for the tools described above affect user decision-making strategy, focusing on when and how the interactive display of information enables fast and frugal decisions. This will then be tested further in supermarket studies, using techniques such as mobile eye tracking, observation and talk aloud methods to determine what people look at and how they use the comparative and cumulative tools. Longitudinal studies are also planned to determine whether the tools proposed have long-term impact on behavior, and how quickly such change

occurs. Various kinds of households (e.g., family, young people, retired single) will be compared in terms of whether and how their shopping patterns and meal planning behavior change when using the tools—different groups of people may be more or less influenced by different types of nudges, and we cannot assume a one-size-fits-all approach.

Whether these various kinds of information delivery can help move people in the direction of better decisions—in the food shopping domain, or in other applications—remains to be seen. Our initial research suggests that simple visualizations can be designed to be information-frugal and emotive – encouraging people to change their behavior at the point of decision-making. But the trick will be balancing frugality and simplicity with *enough* feedback detail to allow people to change their choices at a pace that is sufficiently rapid and noticeable to be rewarding and motivating for long-term behavior change.

Acknowledgments

Thanks to Ricky Morris for creating Figure 1 and Stefan Kreitmayer for developing the simulation shown in Figure 4. We would also like to thank our colleagues Jon Bird from the Open University and Johannes Shöning and Antonio Krüger from Globus Innovative Retail Lab in Germany. The research is partially funded by the EPSRC grant “CHANGE: Engendering Change in People's Everyday Habits Using Ubiquitous Computing Technologies” (number XC/09/043/YR).

References

- Card, S.K., Mackinlay, J.D., & Shneiderman, B. (1999). *Readings in information visualization*. San Diego, CA: Academic Press.
- Consolvo, S., Klasnja, P., McDonald, D. W., Avrahami, D., Froehlich, J., LeGrand, L., Libby, R., Mosher, K., & Landay, J. (2008). Flowers or a robot army?: encouraging awareness & activity with personal, mobile displays. In *Proceedings of UbiComp'08*, 54-63.
- Consolvo, S., McDonald, D.W., & Landay, J.A. (2009). Theory-driven design strategies for technologies that support behavior change in everyday life. In *Proceedings of CHI '09, ACM*, 405-414.
- EDS IDG Shopping Report (2007). Shopping Choices: attraction or distraction? Downloaded 28/08/09 from http://www.eds.com/industries/cir/downloads/EDSIDGReport_aw_final.pdf
- Fasolo, B., McClelland, G.H., & Todd, P.M. (2007). Escaping the tyranny of choice: When fewer attributes make choice easier. *Marketing Theory*, 7(1), 13-26.
- Feunekes, G., Gortemaker, I., Willems, A., Lion, R., & van den Kommer, M. (2008). Front-of-pack nutrition labelling: Testing effectiveness of different nutrition labelling formats front-of-pack in 4 European countries, *Appetite*, 50, 57-70.
- Gigerenzer, G., & Selten, R. (Eds.). (2001). *Bounded rationality: The adaptive toolbox*. Cambridge, MA: MIT Press.
- Gigerenzer, G., Todd, P.M., and the ABC Research Group (1999). *Simple heuristics that make us smart*. New York: Oxford University Press.
- Goldstein, D. G., & Gigerenzer, G. (2002). Models of ecological rationality: The recognition heuristic. *Psychological Review*, 109, 75-90.

- Hertwig, R., & Todd, P.M. (2003). More is not always better: The benefits of cognitive limits. In D. Hardman & L. Macchi (Eds.), *Thinking: Psychological perspectives on reasoning, judgment and decision making* (pp. 213-231). Chichester, UK: Wiley.
- Ishii, H., Wisneski, C., Brave, S., Dahley, A., Gorbet, M., Ullmer, B. & Yarin, P. (1998). ambientROOM: integrating ambient media with architectural space. In *Proceedings of CHI'98*, ACM, 173-174.
- Jafarinaini, N., Forlizzi, J., Hurst, A. & Zimmerman, J. (2005). Breakaway: An ambient display designed to change human behavior. In *Proceedings of CHI '05*, ACM, 1945-1948.
- Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. New York: Cambridge University Press.
- Katsikopoulos, K. V. & Fasolo, B. (2006). [New tools for decision analysts](#). *IEEE Systems Man and Cybernetics – Part A*, 36, 960-967.
- Kuang, C. (2009). Better Choices through technology. Downloaded 28/08/09 from <http://www.good.is/post/better-choices-through-technology/>
- Lin, J.J. Mamykina, L., Lindtner, S., Delajoux, G., & Strub, H. (2006). Fish 'n' Steps: Encouraging physical activity with an interactive computer game. In *Proceedings of UbiComp'06*, 261-278.
- Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge, UK: Cambridge University Press.
- Prante, T., Rucker, C., Streitz, N. A., Stenzel, R., Magerkurth, C., van Alphen, D. & Plewe, D. A. (2003). Hello.Wall – Beyond ambient displays. In *Proceedings of UbiComp'03*, 277-278.
- Rogers, Y., Hazlewood, W., Marshall, P., Dalton, N. S. & Hertrich, S. (2010). Ambient influence: Can twinkly lights lure and abstract representations trigger behavioral change? To appear in *Proceedings of UbiComp'10*, ACM, September 26-29th 2010, Copenhagen.

- Rogers, Y., Lim, Y. Hazlewood, W. & Marshall, P. (2009). Equal opportunities: Do shareable interfaces promote more group participation than single users displays? *Human-Computer Interaction*, 24 (2), 79-116.
- Shultz, W., Nolan, J., Cialdini, R., Goldstein, N., & Griskevicius, V. (2007). The constructive, destructive and reconstructive power of social norms. *Psychological Science*, 18, 429-34.
- Simon, H. A. (1990). Invariants of human behavior. *Annual Review of Psychology*, 41, 1-19.
- Thaler, R.H., & Sunstein, C.R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. New York: Penguin.
- Todd, P.M. (2007). How much information do we need? *European Journal of Operational Research*, 177, 1317-1332.
- Todd, P.M., & Gigerenzer, G. (2007). Environments that make us smart: Ecological rationality. *Current Directions in Psychological Science*, 16(3), 167-171.
- Todd, P.M., Gigerenzer, G., and the ABC Research Group (in press). *Ecological rationality: Intelligence in the world*. New York: Oxford University Press.
- Todd, P.M., & Miller, G.F. (1999). From pride and prejudice to persuasion: Satisficing in mate search. In G. Gigerenzer, P.M. Todd, and the ABC Research Group, *Simple heuristics that make us smart* (pp. 287-308). New York: Oxford University Press.
- Toscos, T., Faber, A.M., An, S., & Gandhi, M. (2006). Chick clique: persuasive technology to motivate teenage girls to exercise. In *Proceedings of CHI Extended Abstracts*, ACM, 1873-1878.
- Tweedie, L., Spence, B., Williams, D. & Bhogal, R. (1994). The attribute explorer. In *CHI Companion Proceedings*, ACM, 435-436.
- van Mensvoort, K. (2005). Datafountain. Downloaded 12/9/10 from <http://infosthetics.com/archives/2005/08/datafountain.html>

von Neumann, J. & Morgenstern, O. (1944). *Theory of Games and Economic Behavior*. Princeton, NJ: Princeton University Press.

Wisneski, C, Ishii, H., Dahley, A., Gorbet, M., Brave, S., Ullmer, B., & Yarin, P. (1998). Ambient displays: Turning architectural space into an interface between people and digital information. In *Proceedings of CoBuild'98*, 22-32.

Wittenburg, K., Lanning, T., Heinrichs, M., & Stanton, M. (2001). Parallel bargrams for consumer-based information exploration and choice. In *Proceedings of UIST, ACM*, 51-60.

Author biographies

Peter M. Todd is professor of cognitive science, informatics, and psychology at Indiana University, Bloomington. In 1995 he moved to Germany to help found the Center for Adaptive Behavior and Cognition (ABC), based at the Max Planck Institute for Human Development in Berlin, to study the simple ways that humans and other animals can make good decisions in appropriate environments. The Center's work was captured in the book *Simple Heuristics That Make Us Smart* (Gigerenzer, Todd, and the ABC Research Group; Oxford, 1999); the sequel, *Ecological Rationality: Intelligence in the World*, covering information-environment structures and their impact on decision making, is in press. Todd moved to Indiana University in 2005 and set up the ABC-West lab there. His ongoing research interests span the interactions between and co-evolution of decision making and decision environments, focusing on the ways that people and other animals search for resources—including mates, information, and food—in space and time.

Yvonne Rogers is a professor of Human-Computer Interaction in the Computing Department at the Open University, where she directs the Pervasive Interaction Lab. From 2003-2006 she had a joint position in the School of Informatics and Information Science at Indiana University (US). Prior to that she was a professor in the former School of Cognitive and Computing Sciences at Sussex University. She has also been a Visiting Professor at Stanford, Apple, Queensland University and UCSD. Her research focuses on augmenting and extending everyday, learning and work activities with a diversity of interactive and novel technologies. She was one of the principal investigators on the UK Equator project (2000-2007), where she pioneered and experimented with ubiquitous learning. She has published widely, beginning with her PhD work on graphical interfaces in the early 80s to her most recent work on

public visualizations and behavioral change. She is one of the authors of the bestselling textbook 'Interaction Design; Beyond Human-Computer Interaction' and more recently 'Being Human: Human Computer Interaction in the Year 2020'.

Stephen Payne is professor of human-centric systems in the Department of Computer Science at the University of Bath. Before moving to Bath, Payne was a Professor of Psychology in Cardiff University and (briefly) a Professor in Manchester Business School. Previously he worked at IBM T.J. Watson Research Center. Payne has worked on cognitive approaches to Human-Computer Interaction since his PhD, on Task-Action Grammars. Most recently he has worked on theories of discretionary task switching and of skim-reading. He is a member of the Editorial Board of Human-Computer Interaction.

Author contact information

Peter M. Todd

Cognitive Science Program

Indiana University, Bloomington

1101 E. 10th Street

Bloomington, IN 47405 USA

Phone: 001 812-855-3914

Email: pmtodd@indiana.edu

Yvonne Rogers

Computing Department

The Open University

Milton Keynes, MK7 6AA, UK

Phone: 011 44 1908 652346

Email: y.rogers@open.ac.uk

Stephen J. Payne

Department of Computer Science

University of Bath

Bath BA2 7AY UK

Phone: 011 44 1225 384085

Email: s.j.payne@bath.ac.uk