Abstracting Nutritional Information of Food Service Facilities Using the Pervasive Healthy Diet Adviser

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Abstract. It would be surprising to find a news publication in the United States today without a mention of words like obesity, diabetes and diet. This is a reflection of the growing awareness worldwide about the importance of a healthy diet in preventing nutrition related chronic diseases like obesity and cancer. A recent study by the United States Department of Agriculture reports that Americans spend more than half of their food dollars on meals at food service facilities. This means that the nutritional content of the food that these facilities provide is an important determinant of national health. We present PHDA, a diet advising application that leverages the power of preventive medicine and ubiquitous computing to help its users choose a healthy diet. Specifically, we discuss the fidelity of different mobile device based peripheral displays in abstracting nutrient data of the food, served in food chains around the country.

Keywords: Peripheral ambient display, Preventive Medicine, Nutritional Information, primary healthcare, ubiquitous computing.

1 Introduction

Four of the top ten medical causes of death in the US today are chronic diseases with well-established links to diet: coronary heart disease, diabetes, stroke and cancer [1]. With 12% of the population suffering from cardiovascular disease [2] and 7% of the population from diabetes mellitus [3] these statistics are alarming. Obesity, which is a dependent and independent risk factor for these conditions, is also at a record high of 64.5%. [4] This is bad news - especially in the existing scenario with rising healthcare costs (8.1 % of the GDP in 1995 to 16.0 % in 2005) [5] and the steady growth of the elderly population (10 % increase since 1996 in population above 65 years). [6] Chronic diseases are known to present with frequent complications, like retinopathy for type 2 diabetes mellitus, which further strain the healthcare system and deteriorate the quality of lives for the patients.

What lies at the epicenter of the web of causation of these ailments is the most universal of human needs, a healthy diet. This seemingly simple concept is fraught

S. Helal et al. (Eds.): ICOST 2008, LNCS 5120, pp. 113–122, 2008.

with complexities and controversies. There have been conflicting views about what comprises a healthy diet from the medical and the scientific communities over time. The most important of such views has been a thirty-year-old belief that dietary fat is responsible for chronic disease also known as the lipid hypothesis. [7] This hypothesis which resulted in a lot of focus on the type of fats, saturated vs. unsaturated, has recently received a string of criticism from the scientific community, eloquently termed as the melting of the lipid hypothesis. Another such philosophy, which has received a lot of commercial attention, is the Atkins diet which predominantly focuses on a high protein intake. Carbohydrate recommendations over time have also been confusing in terms of different forms of consumption like complex starches vs. simple sugars. The historical trends in food production and consumption have not been stable over time either. The rise of highly processed foods and refined grains, abundance of cheap calories from carbohydrates and the use of fertilizers and chemicals in agriculture have all added to the conundrum. Thus the question, "what is it about the American diet that is making Americans increasingly obese and unhealthy?" is not an easy one to answer.

A very important force that has modeled the shape of what Americans eat has been the commercialization of food. The food marketing system, including food service and food retailing supplied about $ 1.02 trillion worth of food in 2005 of which $ 496 billion was supplied by food service facilities that serve meals and snacks for on premise or immediate consumption (food away from home). [8] Full service restaurants and fast food restaurants – the two largest segments of the commercial foodservice market account for more than 77 percent of all food-away-from-home-sales. It is thus impossible to try and address the problem of procuring healthy food without factoring this gargantuan nutritional industrial complex in the scenario.

2 Technology for Human Transformation

Researchers and policy-makers have long argued that Information and Communications Technologies (ICT's) have the potential to improve the quality of life for everyone. In recent years the development of technologies that support individuals in managing their health has become a vibrant yet challenging research area. Specifically there is a rising focus on the use of mobile ICT, both hardware and software to mitigate some growing healthcare issues. This is not surprising when looked at in the light of Gartner's study (August 1, 2007) 'Forecast: Mobile Services Worldwide, 2002-2011' that estimates that the worldwide cell phone usage will top 3.5 billion connections by 2008.

This research focus is a result of an ongoing healthcare revolution that aims to shift the locus of responsibility of healthy living from the healthcare provider to the healthcare receiver. [9] The transformation in doctor and patient attitudes towards health and healthcare and their respective roles provides many opportunities to shift the focus of technology in healthcare from just supporting clinical professionals in delivering high quality care to allowing and encouraging lay individuals to adopt increasingly proactive roles in caring for themselves. Of all the diseases that can be prevented by such active engagement of the affected individual, diet related conditions have the most to gain from. Studies have shown that 1/3 of patients take all

the medicines prescribed to them, 1/3 take some and 1/3 don't take any at all. The levels of non-compliance to medical dietary advice are even higher.

3 Goals

The broad research goal for our group is to empower individuals to make healthy food choices from amongst the available food service facilities near them. In doing so we hope to reduce the burden of diet related chronic diseases like type two diabetes mellitus and coronary artery disease from society. Our approach to this problem is to try and solve it at its source; that is the intersection between the healthcare and the food service industries. We are using a mobile device application that we have developed to work at this intersection. Amongst other things, the Pervasive Healthy Diet Adviser provides its users with the nutrient data of each individual item on the menus of the food service facility near them using peripheral ambient displays. This is made possible after analyzing the nutritional information databases of respective food chains and applying information visualization techniques to represent contextually relevant information from them to the consumers.

We hope that by displaying this information using appropriate metaphors we would enable our users to make healthy diet choices and incorporate this practice in their lifestyles. This information will not fall into the framework of any specific medical recommendation but will allow the user to choose a healthy diet based on the framework that the user desires. One specific goal for our group at this stage is to find most inclusive metaphors to represent nutritional information of foods using ICT's. We aim to segregate such metaphors based on various user characteristics into categories, which are most effective for specific population groups. The metric that we have chosen to labels such a "best fits" is the acceptance of these metaphors by individuals and their consequent ability to encourage behavioral transformation.

4 Methodology

In order to abstract nutritional information using the PHDA we undertook the following steps:

1) We collected the nutritional information databases of food service facilities which were freely available over the internet. We used the information from McDonalds, Burger King, Subway, Chik Fil A, Taco Bell and Pizza Hut for the purposes of our research. The rationale behind this choice was our overarching research goal of reducing the burden of diet related chronic diseases by helping individuals make better choices while eating out. Researching popular fast food takes our study closer to our target population.

2) The nutritional information provided by these facilities was convoluted and hard to comprehend. It was not possible to apply it directly to our research. We then processed each of these databases to extract the calorie and the macronutrient information for each item on their menu. This information was then converted from unusable metrics like "grams of fat" to more practical measures like "the percentage of energy derived from fats". Another problem that we found with this information

Nutrition Facts	Serving Size	Calories	Calories from Fat	Total Fat (g)	% Daily Value**	Saturated Fat (g)	% Daily Value**	*Trans* Fat (g)	Cholesterol (mg)	% Daily Value**	Sodium (mg)	% Daily Value**
Sandwiches												
Hamburger	3.5 oz (100 g)	250	80	9	13	3.5	16	0.5	25	9	520	22
Cheeseburger	4 oz (114 g)	300	110	12	19	6	28	0.5	40	13	750	31
Double Cheeseburger	5.8 oz (165 g)	440	210	23	35	11	54	1.5	80	26	1150	48
Quarter Pounder®+	6 oz (169 g)	410	170	19	29	7	37	1	65	22	730	30
Quarter Pounder® with Cheese+	7 oz (198 g)	510	230	26	40	12	61	1.5	90	31	1190	50

Fig. 1. Existing nutritional information

	Calories	% Fat	% Carb	% Proteins
Hamburger	250	32.4	49.6	19.2
Cheeseburger	300	36.0	44.0	20.0
Double Cheeseburger	440	47.0	30.9	22.7
Quarter Pounder®+	410	41.7	36.1	23.4
Quarter Pounder® with Cheese+	510	45.8	31.3	22.7

Fig. 2. Processed nutritional information

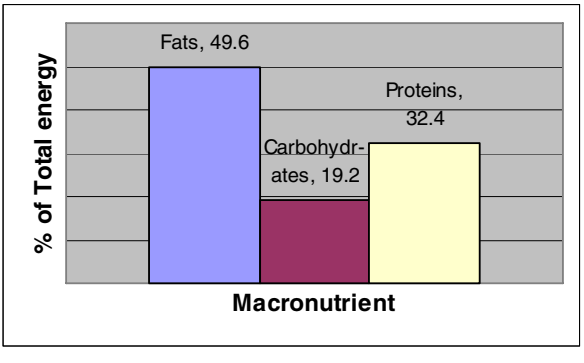

Fig. 3. % energy from macronutrients for Hamburger

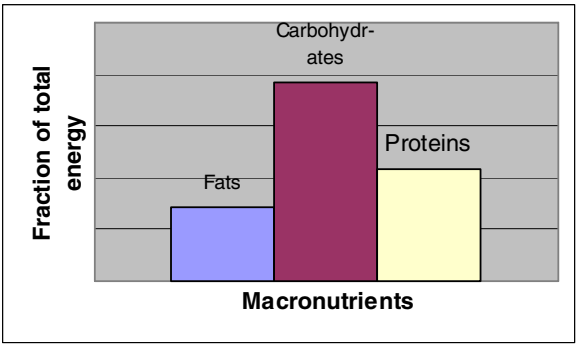

Fig. 4. % energy from macronutrients for Hamburger after normalization

was the calculation of % Daily values based on a 2000 Kilo calorie reference diet. We believe that in this age of ubiquitous computing we can embrace the concept of nutritional individualism and the use of a standard reference goes against that.

3) The processed information for each of the items for these food service facilities was then visualized using bar graphs.

4) On doing do we found that the concept of a balanced diet was hard to visualize using the conventional bar graphs that we had generated for this information. The nutritional recommendations for a balanced diet require that the % of energy derived from each macronutrient category be unequal in a particular proportion. Mayo clinic recommends that a balanced diet should contain 45-65 % carbohydrates, 10–35 % of proteins and 20-35 % of fats. [11] This information goes against the mental image that the word "balanced" construes in our minds. We believe that this is one of the major issues that hinder the success of peripheral displays in trying to represent nutritional information effectively. To avoid this evident pitfall we normalized the distribution of macronutrient representations by multiplying them with different factors. The end result of this intervention was that for the purposes of our research a balanced diet would now be represented by three equal macronutrient bars in a bar graph.

5 PHDA Design

PHDA is a distributed mobile device application that runs on the windows mobile platform. It allows the user to search for restaurants based on the calorie content of the food being served by them. As a result of this search the users are presented with a location based view of the restaurants around them. The restaurant logos are outlined in red or green borders depicting the results of the calorie based search. On selecting a restaurant the user is presented with the items from that restaurant's menu. These results are also color coded using the same paradigm as above. On selecting a particular food item the user is presented with the numerical calorific value of that choice along with a metaphorical representation of its macronutrient balance. On selecting a particular food item its macronutrient representation is converted into the wall paper for the mobile device. In this manner that representation serves as a peripheral ambient display which helps the user in making future dietary choices.

Fig. 5. PHDA start up screen

6 Implementation Process

By relying on a User Centered Design approach, our group performed an extensive review to understand the context described in the introduction of this paper. This review led us to identify healthy nutrition as a curative intervention for those suffering from chronic diseases and a necessity for those trying to prevent these diseases. In this sense, the group identified a very broad user base that varies adequately in several dimensions: gender distribution, age, education, urban or rural lifestyle, religion, culture, cognitive abilities and professions. Taking into account that these dimensions are non-exclusive, we found that profiling the user base was a task of great complexity.

We also identified a considerable gap between the nutritional information that was provided by food service facilities and how well their consumers understood it. The problem was not related to the information not being available as it was made public through different sources like brochures in the restaurant, the food chains website and the National Nutrient Database for Standard Reference [10]. However, the information was not available to the users in a format that is easy to comprehend by them. It thus failed to have any useful impact on their food choices. We did not find any clear standards in place for presenting this data. In many cases, we noticed that the values were displayed in arcane terms like grams per serving or relative to amounts such as the recommended daily intakes that the users were not familiar with. Another related problem we observed was that this information was available in a generic manner for all the users. This further precluded any possibility of it being useful as the concept of a balanced diet is a dynamic and personalized one. On exploring the issue further, we realized that in order to render this information useful the users needed it to interact with their current nutritional state.

Fig. 6. PHDA User Interface

To bridge this gap we have turned our research towards devising graphical interfaces that provide ambient displays using appropriate metaphors to help people understand the nutrient contents of the food being consumed by them in food away from home scenarios. This information will empower the user to understand how adequate certain nutritional choice is for their individual goals (keep their condition in check, weight loss or weight gain) and to quickly recognize which elements of their diet are the most inadequate, and require attention and alternatives. For this purpose we have started a series of focus groups with participants of different ages and backgrounds in which we go over several dimensions of the user and build metaphors (with their corresponding graphics) that can be used to cater to users that differ in:

1. Physical attributes: gender, age.
2. Perceptual abilities: hearing, vision.
3. Cognitive abilities: memory span, literacy and reading level, math skills.
4. Physical spaces: sound levels, lighting, computing platforms available.
5. Cultural and international diversity: languages, information flow, symbols.
6. Special populations and disabilities.

The designed metaphors were simple to comprehend and were specific to locale of United States [fig.]. The next step in the implementation process was the developing of prototypes to evaluate the usability of the metaphors. We developed peripheral

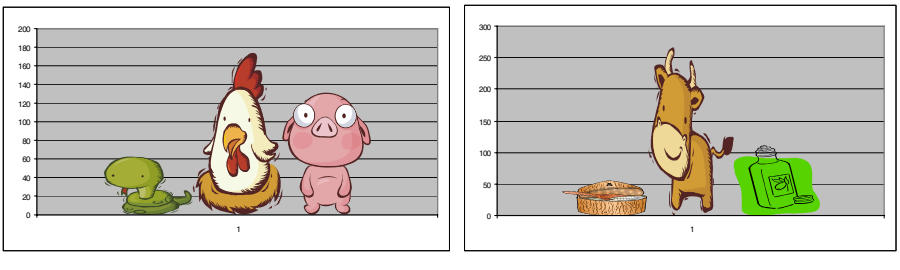

Fig. 7. Metaphor for proteins, fats and carbohydrates

display on mobile interfaces and ran cognitive walkthrough study, which was followed by a heuristic evaluation using neilsen's heuristics in order to discuss the issues concerning the usability and mapping issues of these peripheral images to the dietary concerns of individuals. In one of our displays, we used the metaphor of bread for carbohydrates, cow (beef) for proteins and butter for fats. We hypothesized that the mapping of the dietary habits with these contextual entities would help the user in understanding the importance of the information.

In order to complete the cognitive walkthrough we had a working prototype of a peripheral ambient display images as backgrounds of mobile devices. It was done to gauge the user's response to the ambient display in a mobile setting. We also we wanted to know how these pictures could map on to the dietary guidelines for the individuals. The prototypes were designed to simulate user experience, as the subject would have while using such a nomenclature in next age menu design, mobile health indicators and peripheral orbs. The users were asked to look at the display and tell the examiner the following aspects of the prototype

a) If the diet associated with the display is balanced or not?
b) Do these symbols or displays give enough cues, as to what they mean?

The users of the study were a group aged between 21-40. A sub-group consisted people who had some basic knowledge about dietary facts and the other sub group consisted of people who had no knowledge of facts like importance of fats, proteins and carbohydrates in a balanced diet.

Fig. 8. PHDA Interface

Major emphasis was getting the feedback from the user as to what such peripheral devices mean to them. This 'meaning' is essential in altering the behavior of an individual over a period. The study focused on the following questions

A. Are the assumptions about what the display is supporting correct given the user's experience and knowledge up to this point in the interaction?
B. Will users see the peripheral ambient item, for example, a cow on a background of a mobile display

C. It is one thing for a display item to be visible, but will the user's know that it is the one they have a memory mapping to comprehend information?
D. After the information is taken, will it be enough to modify their behavior patterns over period of time?

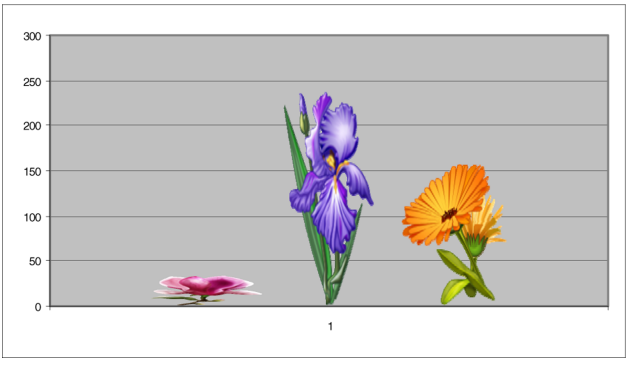

Fig. 9. Flower Metaphor

7 Results

The cognitive walkthrough opened a new realm of relationships between user's understanding, context and mapping to actual parameters depicts in such peripheral displays. The sub group, which had little or no knowledge about dietary elements, had a mental model of a balanced diet as a balance of depicted entities irrespective of what these entities meant. Thus, any three figures normalized to depict a balanced nutritious content was good enough mental model for them. The sub group, which had prior basic knowledge about nutritional facts could relate to the metaphors like cow, butter and bread to the nutritional value. The imbalances in the size of these entities signified the imbalance in the nutritional content. The focus group resulted in understanding the user space and the concerns. The sessions are yet to be transcribed but the overall picture seems to support the hypothesis that people can relate to such peripheral displays with the nutritional facts easily as compared to numbers.

8 Conclusion

The results confirmed that the user could relate these peripheral display images with the nutritious content of a given food item. The power of preventive medicine and ubiquitous computing is used to build a diet advising application PHDA in order to help its users choose a healthy diet. Specifically, we discussed the fidelity of different mobile device based peripheral displays in abstracting nutrient data of the food, served in food chains around the country. We would implement the knowledge gained in this exercise to create new experiences in food item menus, mobile nutrition detector, health based menu display. Thus, our work will continue in this sense to

build a stronger map of metaphors and take advantage of multimedia and connectivity to data sources provided by many of the computing platforms available to users today.

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