FOOD INFORMATION SYSTEM

A Thesis

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By

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Food Information System

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Classmates

and

My family

Glossary

Food products: Edible artifacts processed and packaged in facilities

Bar code: Combinations of dots, lines and areas used to identify an item

Database: A systematically arranged collection of information

Abstract

Food-related diseases torment numerous people and cause exorbitant costs. For those who are concerned about food, labels on the packages are the most reliable source of information about nutrients and ingredients. However, current food labels make them frustrated with the low legibility and intelligibility. In this study a food information system was developed from comprehensive user research. Using an accessorized device, user scans a food product and it displays personalized information, based on individual criteria settings. Intuitive user interface was also designed and embedded in the personal device. Field tests were conducted to evaluate the system and understand user experience.

1

Introduction

Food is a requisite for survival and a means of satisfying a basic instinct. It is also often regarded as a delicate culture and a way of social communication. Penetrating the importance of food and the indulgence in food, humankind has developed not only various styles of food but also diverse technologies to enhance flavors, colors, tastes and shelf life to gratify desires. Owing to these constant efforts, there are ample food products made from numerous ingredients and additives available. Those edible artifacts offer accessible epicureanism to consumers and economic prosperity to manufacturers.

However, abundant food products have simultaneously induced unforeseen side effects. There are a huge number of people suffering from food-related health problems such as obesity, diabetes and food allergies, often as direct result of food ingestion. While the population of patients has grown steadily, the increment has increased rapidly in the recent decade. One out of four adults in US is obese, one million Americans are diagnosed with diabetes every year and peanut allergies doubled between 1997 and 2002 in children under 5 [1]. The raging health problems not only torment patients and their families but also incur huge social expenses. As of 2007, there are more than 17 million diabetic and 50 million allergic Americans and $93,000,000,000 dollars were spent for obesity-related medical care in a year [2].

Since definite cures for those health problems are not yet available, many medical professionals emphasize prevention and management. Diet is regarded as an especially important means for the patients to manage their conditions. It is very common that strict diet plans and controlled regimens are accompanied with medicines as medical treatments [3-5]. However, recommended healthful foods are different depending on individual conditions such as unique physical constitutions and diatheses (susceptibilities to diseases) [6]. For example, people having food allergies should avoid specific food and ingredients harmful or fatal to each person.

As it is crucial to get accurate information about food, according to surveys, food buyers are mostly dependent on food labels on packages as the source for their information [7]. Since the labels are a part of the package, the contents must be handy, straightforward and highly accessible. However, most participants in those surveys complained about the labels, which were not legible and understandable [8].

Fine print of the enumerated ingredients, written in technical terms, makes them hard to read and understand [9-12]. Moreover, it restrains food buyers from investigating whether any problematic ingredients were contained in a food product [13,14]. Generalized warnings about selected principal allergens are not very helpful for people needing special regimens [15]. Potentially harmful preservatives are veiled behind embellished phrases such as ‘added to keep freshness’ and default serving sizes suggested by food manufacturers are unconscionably small [16,17]. In other words, current food labels do not provide sufficient information, reflecting food buyers’ personal needs.

Those immediate problems induce secondary troubles. Consumers having health problems normally spend much longer time at supermarkets checking each ingredient. Allergic people are extremely concerned about elements of food products that may be fatal to them. Because of the distress, they stick to specific familiar foods and hesitate to try new ones. Some of them keep buying same articles of food every time and traveling to several grocery stores to complete their food shopping. Current food labels have baleful influences on their food shopping and quality of life [18,19].

Responding to those obstacles, there have been approaches to facilitate investigation of the food labels, mainly aiming at nutritional enhancements. While some health support groups offer nutrient-oriented tools, USDA has opened a specialized web site [20-23]. In 2007, the UK launched traffic light style labeling using three colors to indicate the amounts of common nutrients and the system is going to spread to other countries [24,25]. Technology-embedded attempts include food scanning kiosks and nutrition scanners [26].

Nevertheless, web-based information has shortcomings in usability where Internet access is limited. There are also still considerable numbers of people who are not familiar with computers [27]. While the improved versions of printed labels offer a better way to understand, most of the same problems remain unsolved. The store-based information kiosk has definite limits in propagation due to its bulkiness and costs and phone-embedded software is not approachable for those who do not know even how to send a text message [28].

In this study, a food information system was designed to deliver information about nutrition, calories and ingredients of food products to user in a personalized manner. Its elements – a personal device, a user interface and an overall system – work synergistically to solve problems with existing food labels. The system also contributes to the health promotion by helping people make smart choices of food easy and fast.

2

User Research

2.1. Surveys

Since this study dealt with user-centered topics as well as user-oriented goals, defining the user group was imperative. At the early stage of this study, several surveys were conducted to figure out potential users' demographic backgrounds, health conditions, food shopping patterns, sources of food information and problems with the sources. The questionnaire commonly used for those surveys is shown in Appendix 1. As methodological deployment, diverse survey methods were adopted to understand people's needs effectively as follows:

On-site interviews at grocery stores with food buyers

Web-based surveys of the general public

Focus group meetings with people having health problems

Group surveys of local support group members during their regular meetings

The user research began with surveys of general public to collect comprehensive thoughts. For the on-site interviews, shoppers were asked to participate in the surveys at local grocery stores. It was effective to get narrative responses like conversations; however, the method definitely took a long time to collect a sufficient number of answers and some of the people refused to share their time for the interview. Regarding web-based surveys, in the quantitative aspect, it was noteworthy that a considerable number of responses were collected among four methods described above, seemingly owing to convenient participation.

From those surveys of general public, it was revealed that participants having health problems showed more interest in this study than those not having such issues. So further research was focused on people who either suffered from health problems or had such family members. It was also expected that this study would be more beneficial to them.

Focus group interviews allowed thorough and narrative responses from open-ended conversations, creating a personal and intimate atmosphere. Voluntary participants, normally having chronic health problems, were interviewed at public places such as offices, coffee shops and restaurants. On the other hand, the face-to-face method had intrinsic limitations in the number of participants and length of time for both preparation and action.

Group surveys offered reciprocal convenience for both interviewer and interviewees in terms of time and space. The groupwise method was especially effective to collect answers from peers sharing common concerns. Members of Rhode Island Food Allergy Network and American Celiac Disease Support Group took part in the surveys.

The common questionnaire was prepared by the help of Item NPD Company having experience in customer surveys for product development. Detailed breakdowns of the surveys are as follows:

On-site interviews (25 participants)

Stop n Shop supermarket (Pawtucket, RI): 8 participants

Stop n Shop supermarket (Seekonk, MA): 5 participants

Whole Foods Market A (Providence, RI): 3 participants

Whole Foods Market B (Providence, RI): 4 participants

Back to Basics grocery store (East Greenwich, RI): 5 participants

Web-based surveys (155 participants)

Surveygizmo.com: 138 participants

Surveymonkey.com: 17 participants

Focus group interviews (21 participants)

Providence, RI: 8 participants

Cranston, RI: 4 participants

Foxboro, MA: 6 participants

Sharon, MA: 3 participants

Group surveys (140 participants)

Providence, RI: 76 participants

East Greenwich, RI: 64 participants

Total: 341 participants

2.2. Results

The responses were analyzed to understand people's psychological tendency and behavioral modality, influenced by health problems. The results were also compared with previous surveys to ascertain whether there had been any significant changes.

Among 341 responses, as illustrated in Fig. 1, the number of female food buyers (266 participants) surpassed male (75 participants) by far and the preponderant ratio between genders coincides with the results of American Time Use Survey conducted by the US Census Bureau from 2003 through 2007, which revealed that women are more responsible for buying food in families [29].

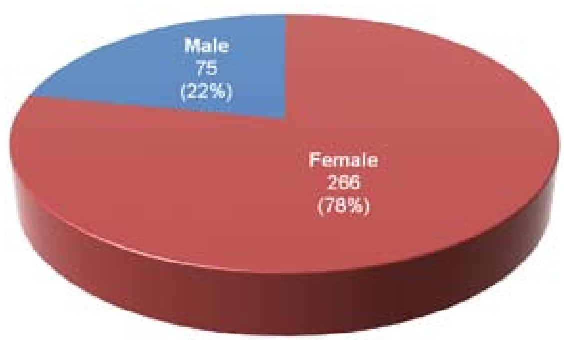


Fig. 1. Gender ratio of participants

To questions asking health conditions, 73% of the participants answered that they or their family members had health problems and the details are shown in Fig. 2. Regarding individual alimentary standards, a majority of the respondents (81%) had personal criteria for food products and Fig. 3 marshals their responses. They also cited various food ingredients they did or did not want to ingest, mostly for the sake of management or prevention of those health problems.

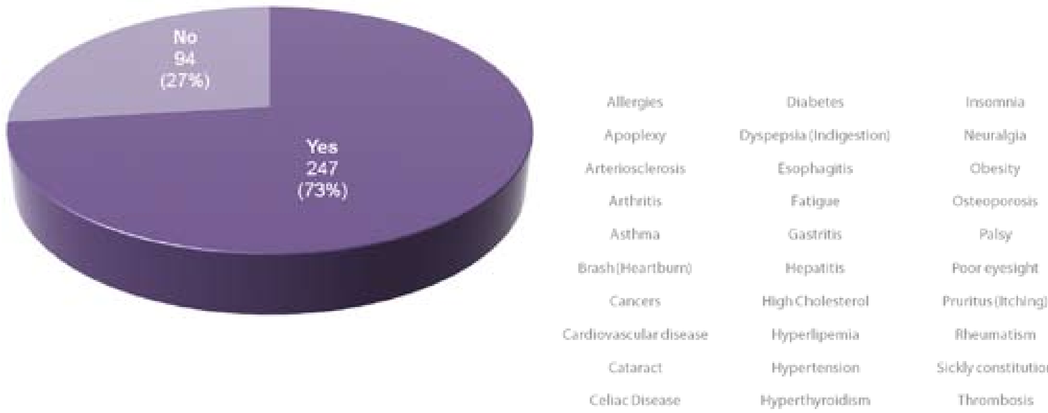


Fig. 2. Personal health problems

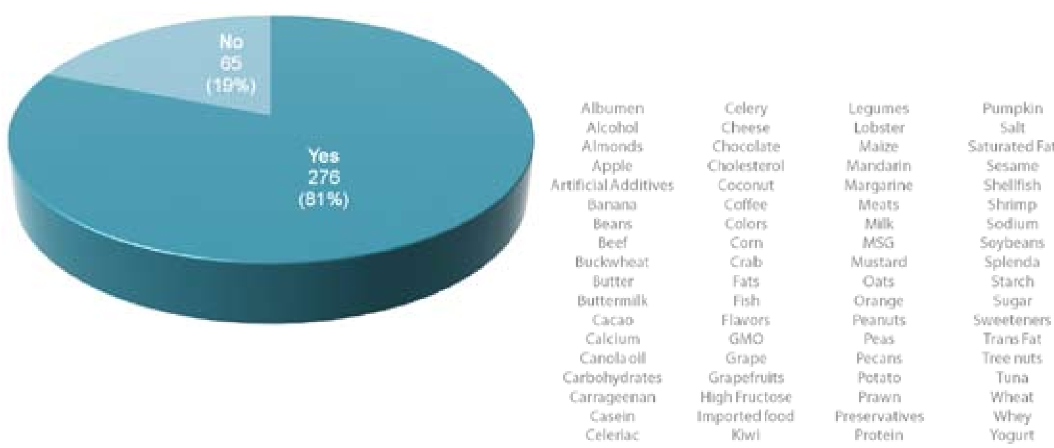


Fig. 3. Personal criteria for food choices

As demonstrated in Fig. 4, a large percentage of participants picked food labels on packages as a principal source of getting information about food products. However, overall satisfaction in the labels was considerably low. The participants gave low scores especially to legibility, intelligibility and possibilities of personalization – serving size and applicability of the information to their own health conditions – while they had relatively less dissatisfaction with the scope of the information (Fig. 5).

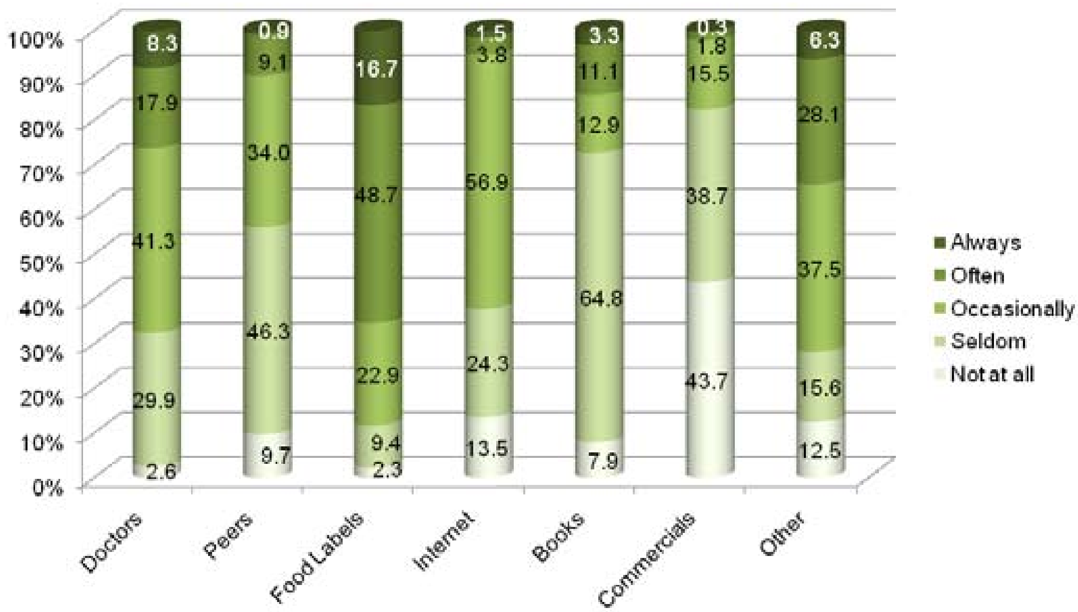


Fig. 4. Sources of food information

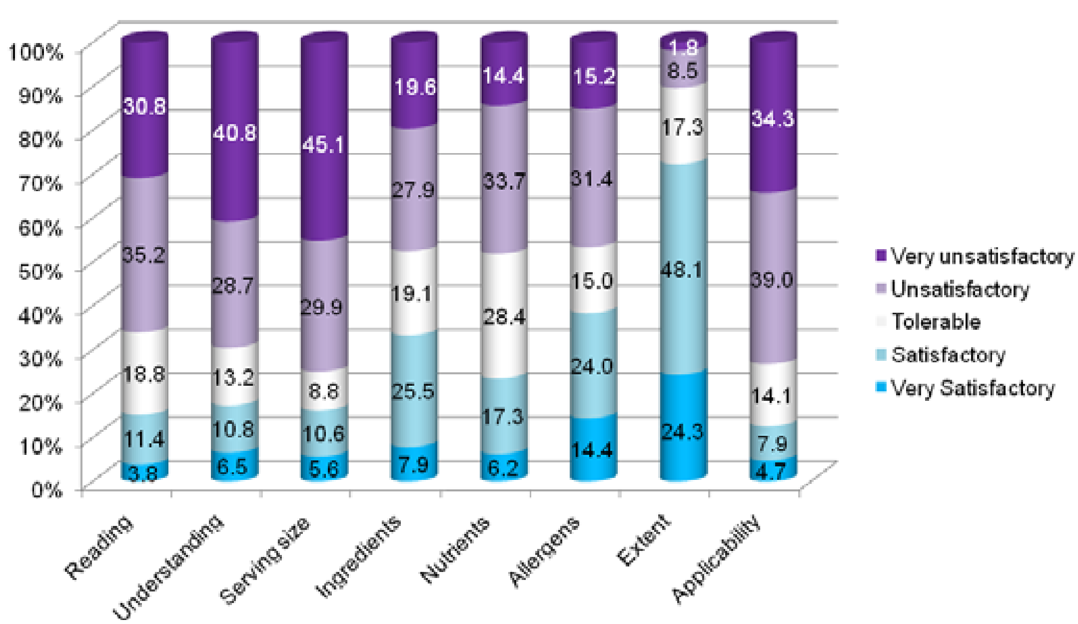


Fig. 5. Degrees of satisfaction with food labels

In the interviews, many respondents pointed out difficulties in reading fine print as well as understanding terminologies. Since enumerated chemical names and arbitrary initials of ingredients were crammed into a tiny space, it was very hard for ordinary consumers to figure out what was contained in the food. Even though the information covered the full extent of the ingredients, the recondite contents in fine print were not helping the food buyer's choices sufficiently, but instead confusing their decision-making.

Another remarkable finding from the surveys was participants' strong needs for personalized information. The results obviously showed that many people recognized the important influence of food on their health and they required special type of food information reflecting their individual health conditions and preferences. However, since the food labels were intended to give general information to the public, the possibilities to modify or customize the contents, based on an individual's own criteria, were not allowed. They also criticized the difficulty of utilizing the labels for diets. Serving sizes suggested by food manufacturers were often so small that consumers were confused in calculating the actual values based on their own eating habits.

Regarding people's food shopping patterns, the participants answered that they bought food 2.4 times a week, spending 1.1 hours per visit on the average (Fig. 6 and 7). Compared with the governmental survey (2.1 times and 41 minutes, respectively), there was no significant difference in the frequency of food shopping. However, the respondents in this study stayed considerably longer at grocery stores than the national average. Especially people having health problems (1.3 hours) spent more time than those who had no health problems (34 minutes) and the prolonged shopping time was mainly the result of scrutinizing every food ingredient.

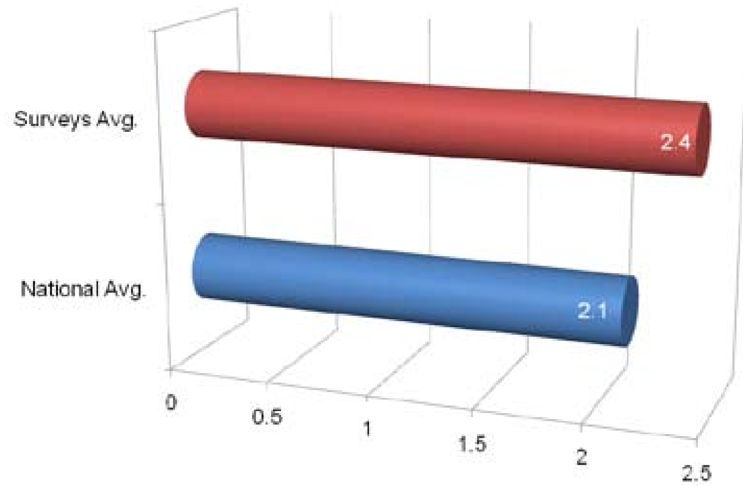


Fig. 6. Frequency of food shopping (times per week)

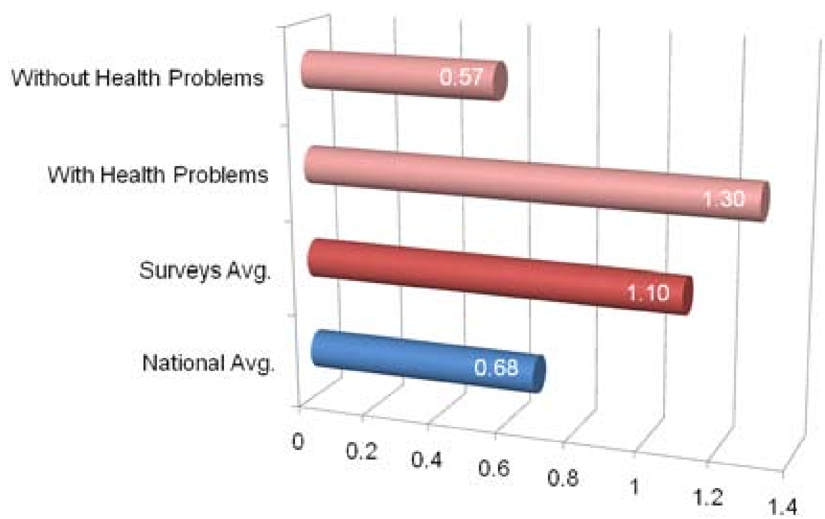


Fig. 7. Duration of food shopping (hours per visit)

In the surveys, there were some astonishing cases. A participant spent 5 hours every week just for food shopping. Another woman, suffering from diabetes, multiple food allergies and asthma, had family members also having diabetes and three different food allergies. She prepared a long list of food products and ingredients that should be avoided. However, safe food products for the family were very limited and even hard to get from neighborhood groceries. The circumstances had forced her to travel four special food stores every week to buy the same “proven-as-safe” foods.

In another interview, a woman mentioned that she always carried EpiPen (emergency treatment injection) for her 8-year-old son, having a life-threatening peanut allergy, after he experienced anaphylaxis just by biting a cookie, given as “energy food” before a soccer game. Whenever she went food shopping, her child clamored for candies and sweet stuff, especially newly launched ones. However, she never gave in to his demands because casual ingestion might be fatal to him. Instead, she often drove for two hours to buy nut-free cakes at a specialized bakery for her son.

To sum up, the user surveys revealed that current food labels caused not only the firsthand problems such as the lack of legibility, intelligibility and personalized information, but also secondhand issues, which affected people’s life much more, such as prolonged shopping time, long trips to the grocery stores, excessive anxiety, clinging to specific foods and avoiding unfamiliar ones.

3

Design

3.1. Intent

The problems of the food labels, found from the user surveys initiated the design process of the food information system. The design initiative aimed to promote the user's quality of life by helping them make smart choices of food products.

The process was divided into three sections – system, devices and user interface – to develop the solutions effectively. The system was designed to organize the elements logically and manage them stably. On the basis of the system, the personal devices were created utilizing organic associations and ergonomic factors. The intuitive user interface was embedded in the device to establish a close emotional bond with the users. In the design process, each of the section was focused on delivering the senses of safety, security, reliability and affinity to the user.

3.2. System

In the food information system, the user scans a bar code on a food package using the personal device and it displays information about calories, nutrients and ingredients of the food, based on personal criteria preset by the user. Individual factors, such as health conditions, preferences, diet plans, eating habits and religion can be bases of the criteria.

The personal device, consisting of four components of food databases, scanner, memory and display, is a core element of the system. The **food databases** are collective information about manufacturer, product name, calorie, nutrition, ingredients, package size and product code of each food product. FDA and USDA food databases are stored in the device and updated automatically to reflect any changes, food alerts and recalls by a remote server wirelessly [30-32]. The **scanner** is an optical reader detecting bar codes and the **memory** stores the user's personal settings and history of use. The **display** shows the information through user interface (Fig. 8).

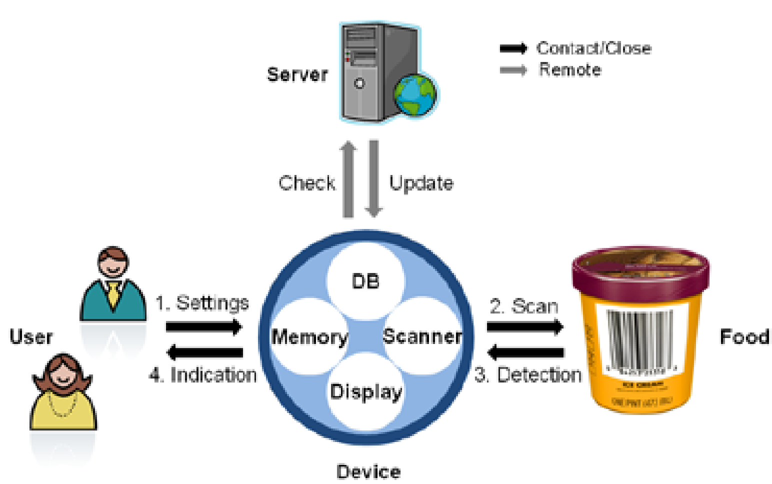


Fig. 8. Structure of food information system

3.3. Devices

3.3.1. Main Device

The personal device is the most important part of the food information system. As a medium for interactions between the user and the system, it allows the user to input settings, reacts to the user's operations and displays options and results. Therefore, sensuous factors such as appearance, contour, colors, size, arrangement of buttons, haptic feel and consonance with the user's lifestyle were seriously considered in the design process. The personal device was ultimately designed to give the values of the food information system – safety, security, reliability and affinity – to the users.

Fig. 9. Ideation: Lifesaver (left), magnifying glass (right) and device (center)

In the ideation process, the basic appearance of the device was inspired by a lifesaver, as illustrates in Fig. 9. As a lifesaver rescues people from danger, this device was designed to provide the same feelings of relief and protection to its user, by sharing formal similarities with the familiar rescue equipment such as red lines and a center circle. The strongly established understanding of the lifesaver would be very helpful to build a trustworthy impression of the device to the users.

The other reference of the outward form of the device was a magnifying glass, used to scrutinize details and to see the unseen. This simple optical tool is also intimate to most people and still being utilized in many applications including reading fine print. Therefore, introducing conspicuous convexity to the contour of the device could be a trigger, making the users recall the functional commonness as well as configurational analogy unconsciously.

The appearance of the device, visually connected to these associations, is illustrated in Fig. 10. On the front side, a round screen is at the center (white circle) and three illuminated touch buttons (,  and ) are arranged on the surrounding rim. Each touch button has a dimple on surface to locate a finger on its right position. In the user interviews, seniors and diabetic people explained that their fingertips got less sensitive than before. The physical locators were designed to help them find and touch the buttons easily and correctly.

Fig. 10. Front of personal device

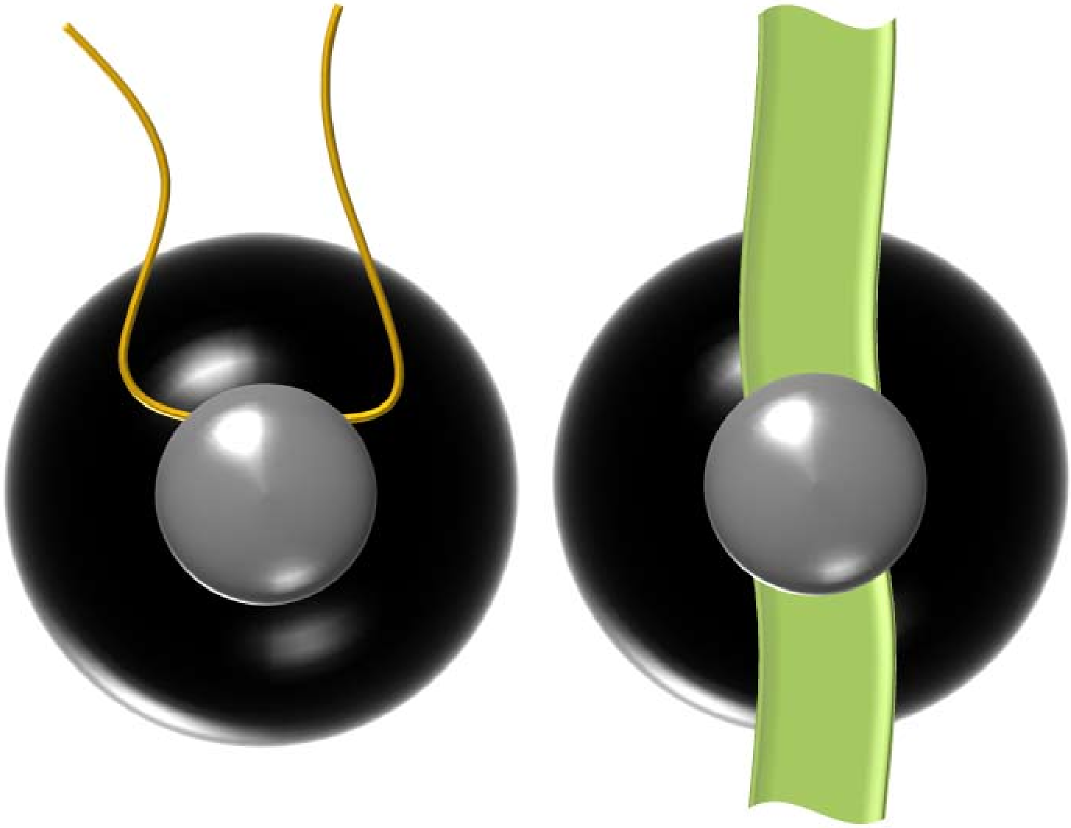


Fig. 11. Back of personal device with interchangeable connectors

Fig. 11 shows its back with an interchangeable connector, which is a part of a neck strap, a wristband or a clip. With any one of those attachments, the device gets accessorized and it empowers the user to carry the item like an ordinary fashion item. The user also does not need to remember to bring it for food shopping.

Another merit of the accessorizing is elimination of the user's psychological barrier against the device. Given the epistemological hypotheses, arguing cognition of an object is formed from its appearance, it is justifiable that attitudes toward valuables and sundries are quite different [33]. The transformation of the technology-intensive instrument into a familiar accessory was intended to avoid the evocation of technophobia and it was confirmed by the users in field tests.

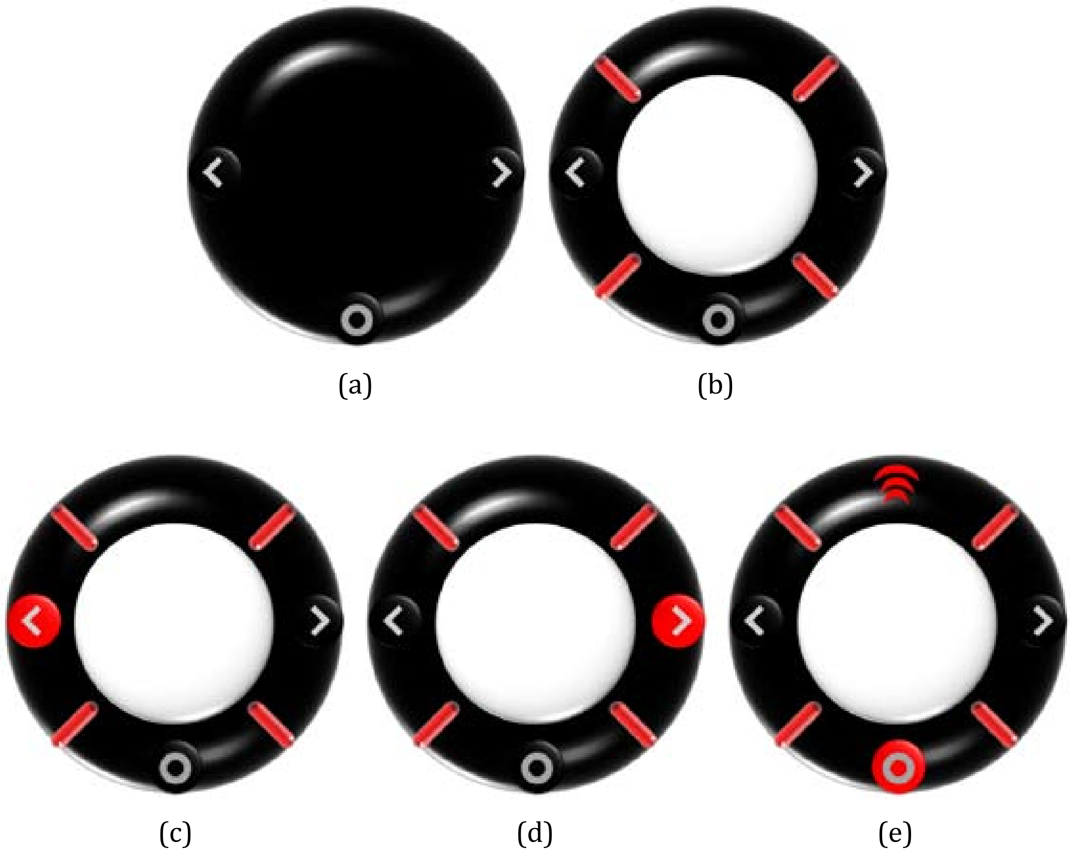


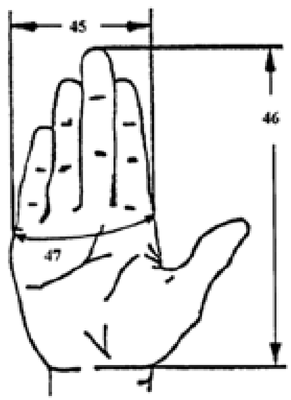
Fig. 12. Basic operations: (a) Turned off, (b) Turned on,

(c) ‹ button touched, (d) › button touched, (e) ◎ button touched for scan

Fig. 12 demonstrates basic operations of the device. When it is turned off, only three buttons (‹, › and ◎) are visible from the black background of the body (a). After powered on by touching the ◎ button for longer than 1 second, four red stripes as well as a white screen come out to emphasize its visual coherence with the lifesaver (b). While either of two buttons (‹ and ›) is touched to adjust values (c, d), it is illuminated. The ◎ button is used to select an option or scan a food (e). An auxiliary indicator (≋) symbolizing the scanning wave is lit while the device scans.

45 Hand breadth. The breadth of the hand, measured across the ends of the metacarpal bones (metacarpal-phalangeal joints).

	Sample		Percentiles 1st	5th	50th	95th	99th
A	Men	cm	8.1	8.4	9.0	9.8	10.0
		(in)	(3.2)	(3.3)	(3.5)	(3.9)	(3.9)
B	Women	cm	7.1	7.3	7.9	8.6	8.9
		(in)	(2.8)	(2.9)	(3.1)	(3.4)	(3.5)



46 Hand length. The distance from the base of the hand at the wrist crease to the tip of the middle finger.

	Sample		Percentiles 1st	5th	50th	95th	99th
A	Men	cm	17.3	17.9	19.3	21.1	21.9
		(in)	(6.8)	(7.1)	(7.6)	(8.3)	(8.6)
B	Women	cm	15.9	16.5	18.0	19.7	20.5
		(in)	(6.3)	(6.5)	(7.1)	(7.8)	(8.1)

47 Hand circumference. The circumference of the hand, measured around the knuckles (metacarpal-phalangeal joints).

	Sample		Percentiles 1st	5th	50th	95th	99th
A	Men	cm	19.2	19.9	21.3	23.0	23.7
		(in)	(7.6)	(7.8)	(8.4)	(9.1)	(9.3)
B	Women	cm	16.7	17.3	18.6	20.0	20.7
		(in)	(6.6)	(6.8)	(7.3)	(7.9)	(8.2)

Fig. 13. Anthropometric analysis of hand

To determine optimal dimensions of the device, recent anthropometric data, compiled by the Department of Defense and NASA, were adopted (Fig. 13) [34,35]. Considering that a large portion of the users of the device would be women, the size was determined to fit in even a small hand. The curvy contour helps the user grip it naturally like a pebble. The device was also designed symmetrically for ambidextrous use. Measured dimensions of the device are shown in Fig. 14. The naturally comfortable grip was confirmed by more than 100 users in the field tests.

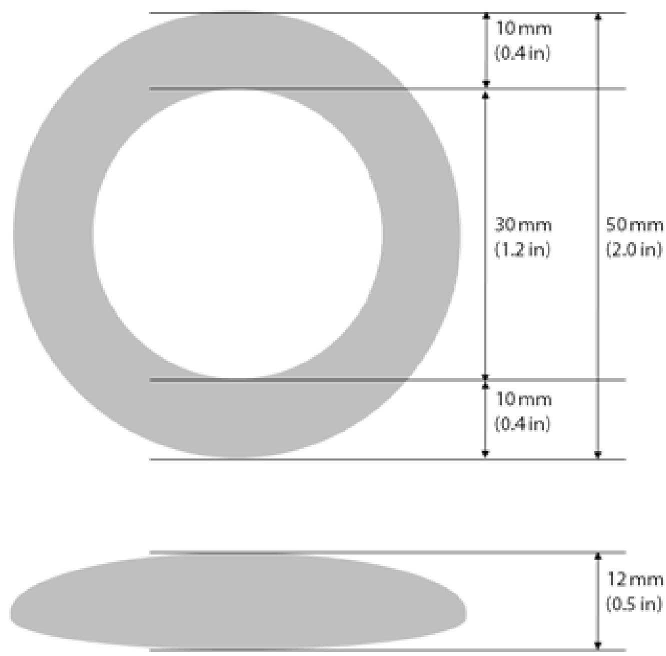


Fig. 14. Dimensions of the device

3.3.2. Device for Children

One of the most frequently discussed issues in the user interviews was about children. Mothers of allergic children always worried about casual ingestion of allergens. There are numerous food products containing problematic ingredients and some of them may be fatal to the children. However, many children are not be able to fully understand their own special health conditions and control themselves. Many accidental cases occurred while parental care was unavoidably and temporarily unavailable. For example, allergen-containing refreshments might be given to an allergic child during a group activity practice, after a sports game or in a friend's house.

In this study, an additional device was designed to protect the children (Fig. 15). A simplified version of the device, with no screen and buttons, was equipped in a cartoon-like monkey doll, which could be strapped around a child's upper arm like a toy. Pulling out its retractable tail activates the device and lets the child scan a bar code on a food product with the tail tip. The color of the tip changes to red or green to indicate the results, based on the personal settings created by parents. In addition, the doll includes the child's name and health problem and instructions for an emergency. The toy-styled device gives reinforced safety to both the child and the parents while it teaches about special health conditions and preparedness.

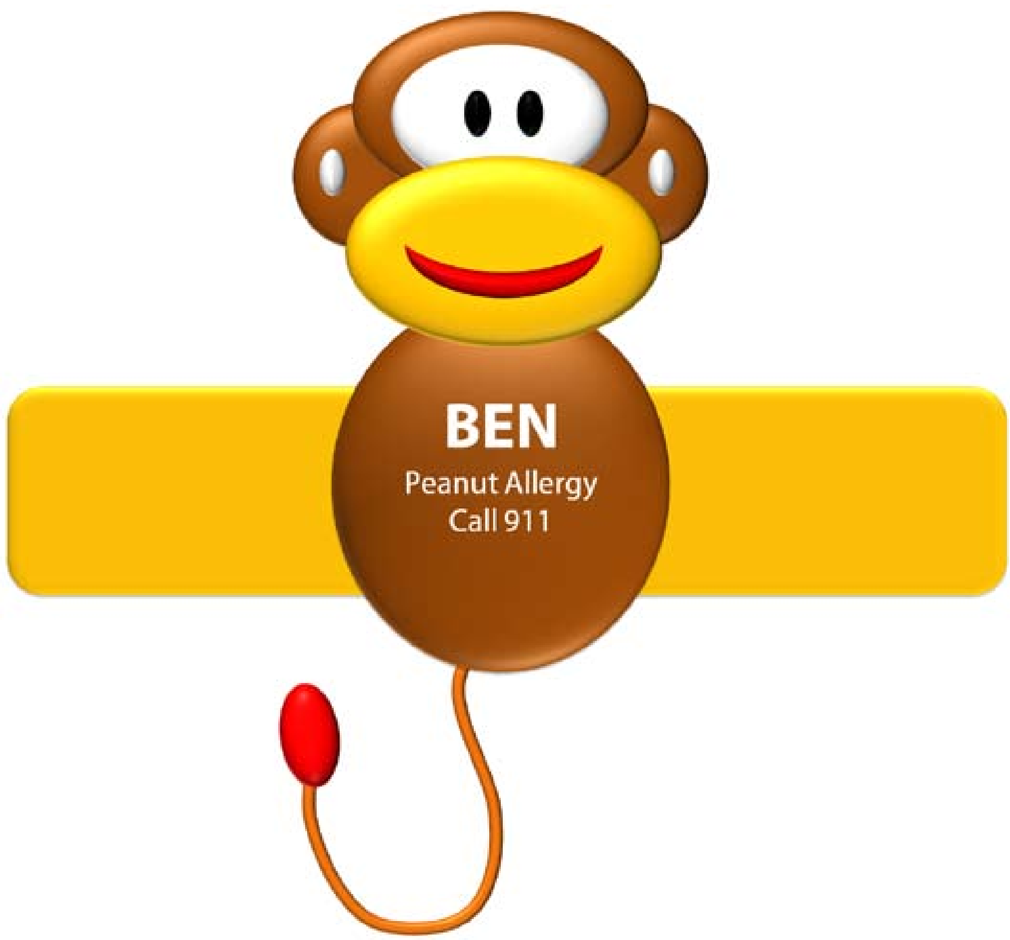


Fig. 15. Device for children

3.4. User Interface

While the device is being used to scan food products or create personal settings, the user interacts with the device through the interface, displayed on the screen. Since the device provides important, sometimes vital information to its user, the interface should be a reliable carrier for fast and accurate communication. Therefore, functional factors, such as legible font and size, effective arrangement of elements, less number of touches, systematic hierarchy and facile navigation, were embodied in the user interface design.

Meanwhile, formal factors, such as intuitive graphics, appealing colors, conformity with the device appearance and universal coherence were also taken into account. Those emotion-oriented considerations were especially necessary to induce the user's psychological intimacy with the system and maximized usability.

The logical structure is shown in Fig. 16 using representative screens. The circular user interface fits in the center screen of the device, conforming to the round contour. In each screen, use of intuitive icons and large fonts creates information, which is distinctly legible and certainly understandable. While mild azure, producing an impression of clear sky, was introduced to the overall user interface, indigo was partly used for contrast. The azure is also regarded as an illness-soothing and pain-treating color in chromotherapy [36].

Once the device is turned on, there are two modes – **Personal Settings** and **Scan** – available under the main menu. Four subgroups – **Calories**, **Nutrients**, **Ingredients** and **Categories** – are present under the personal settings mode. The simple hierarchy and rationally organized features enabled fast operations and easy navigation by using only three buttons (<, > and ◎). For example, just touching the ◎ button for longer than 1 second jumps to a higher level from any screens. The user creates individual criteria under four subgroups settings as follows:

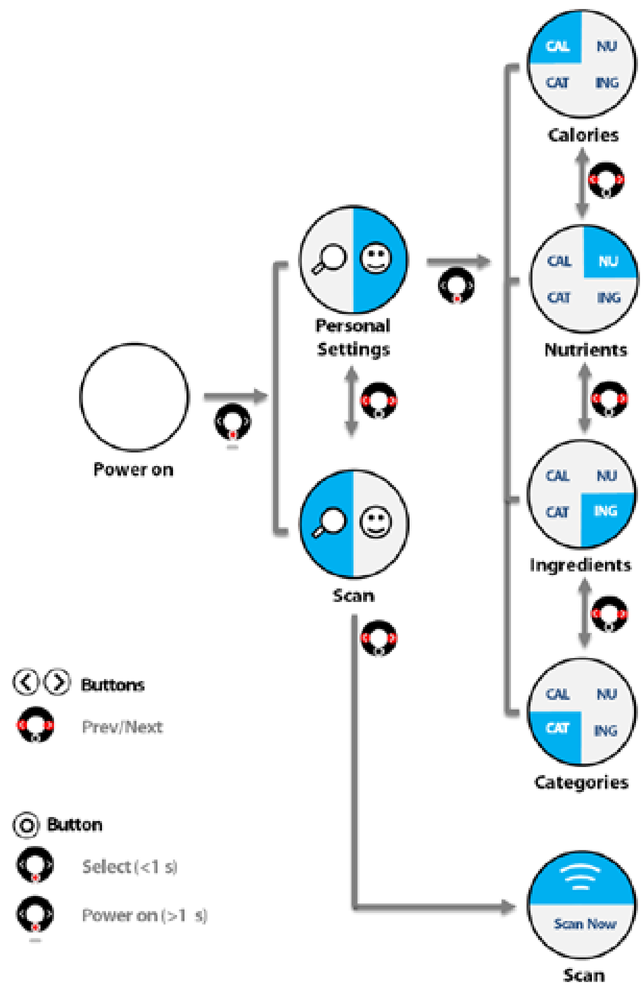


Fig. 16. Two modes: Personal settings and scan

Calories: The user sets a desired amount of calories for daily ingestion and it is the standard for daily values (DV) of each nutrient. Normally it is suggested as 2,000 kcal, however, people on a diet, pregnant women and athletes may need different standards.

After changing calories using and buttons, a desired value can be set by touching the button. Process of setting 1,500 kcal as the user's personal daily standard is depicted in Fig. 17 as an example.

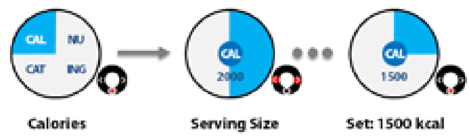


Fig. 17. Calories settings

Nutrients: The user looks up specific nutrients, like fat, carbohydrate and sugar, in the databases and sets maximum amounts for each nutrient, in percentile values to the daily standard. As demonstrated in Fig. 18, the user looks up fat and then sets 8% as a maximum ingestion level from a single food product. The user interface offers a dictionary-styled searching method.

Fig. 18. Nutrients settings

Ingredients: The user looks up specific ingredients, like peanuts, wheat and milk, and selects a preference among three different levels of ingestion (♥: Set as favorite/•••: Allow traces/✖: Reject) for each ingredient. The ingredients subgroup helps the users avoid problematic substances. Allergic users may create settings to block specific allergens completely or allow traces depending on personal tolerances as shown in Fig. 19. It is a preventive way to protect from accidental or misinformed purchase and ingestion that might be fatal to the user. In a reverse way, it is also possible to use the function positively to investigate a food product whether it contains user's favorite ingredients.

Fig. 19. Ingredients settings

Categories: As suggested in Fig. 20, the user looks up specific categories, like preservatives, gluten and artificial colors, and selects a preference from two options (⭘: Accept/✖: Reject) for each category. While more than 3,000 food ingredients are used in US, the categories settings give a comprehensive way instead of searching every ingredient. The categories settings also offer a convenient tool to screen out embellished ingredients, expressed like "added to keep freshness" in place of "preservatives added".

Fig. 20. Categories settings

After the user finishes making the personal settings, the device is ready to scan food products. When the user scans a bar code on a food product using the ◎ button, the device detects it and refers to the internal food databases to extract corresponding information such as the product name, manufacturer, package size, calories, nutrients and ingredients of the food. After comparing the information to the user's personal settings, the device displays the results on its screen. After scanning, there are two cases – instant warning and personalized serving sizes – possible as follows:

Instant Warning: If a food product contains any ingredients the user has rejected, the device displays a warning and stops further investigation of the food. For example, if the user chose "reject" against peanuts under the ingredients settings, the device shows a warning screen when it scans a food product containing peanuts in any form (Fig. 21). The preventive function also works where food alerts or a recall is ongoing.

Fig. 21. Instant warning

Personalized Serving Sizes: If a food product does not contain any problematic ingredients based on the user's settings, the device shows nutrition information about the food. First, it checks the amounts of nutrients from the default serving size, suggested by the manufacturer. The information about the nutrition is then compared to the maximum amounts of each nutrient that the user already made under the nutrients settings. After checking the graphic results of the results on the screen, the user can adjust the serving size depending on individual eating habits and preferences.

A pie chart interface helps the user perceive and change the portions at a glance. As the user increases personal serving size, cautions or warnings may be given if there is any excessive nutrients compared to the user's settings. The results are displayed on the screen utilizing three colors of traffic light for the user's intuitive understanding. For example, when the user scans a bag of chips, the device shows a brief information of the food and then indicates amounts of calories and nutrients, to be ingested from a ¼ bag (suggested serving size), in green if the all of those amounts are lower than the user's settings. As the user increases the portion to ¾ of a bag (usual eating portion), the device shows corresponding information about the calories and the nutrition. If the values exceed personal settings, made under the calories and the nutrients settings, it gives cautions (in yellow) or warnings (in red), depending on the discrepancies (Fig. 22). The overall scheme of the user interface is demonstrated in Appendix II.

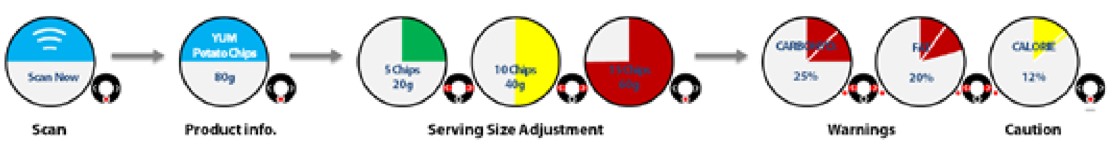


Fig. 22. Personalized serving sizes and results

4

User Experience

4.1. Devices

Using the models of the personal device (Fig. 23, 24), several field tests were conducted at Back to Basics grocery store (East Greenwich, RI) and Stop n Shop supermarket (Pawtucket, RI). In the tests, the device design and the usability of the food information system were evaluated by participants including members of the American Celiac Disease Support Group. After each run, there were open discussions or interviews with the people to understand user experience.

The participants showed great interest in the personal device in terms of its personalized information and accessorized design. It was favorably received especially by the people having health concerns, as an unprecedented shopping aid. Most seniors were satisfied with the excellent legibility of the display and people having different hand sizes endorsed its comfortable grip.

Since this study dealt with health issues, professionals in health care, dietetics, medical research, food safety and public health also participated in the process as advisors. In the meetings with those professionals, they appreciated the potential of the food information system as a promising tool to promote personal health and propagate public awareness of health. Possibilities as an aid for fighting obesity and managing family nutrition were also suggested.

Fig. 23. Models of personal device

Fig. 24. Accessorized personal device

4.2. Application

In the field tests, the food selection process was simulated to estimate the effect of the food information system. First, three participants were asked to decide whether to purchase five listed items scattered on the shelves in the store, after investigating each product using their original method. It was used as controlled group.

Next, those people did the same process using the personal devices developed in this study, with new shopping lists. The elapsed times were recorded and compared. As depicted in Fig. 25, the average shopping time was reduced by 32 percent when the device was adopted, though there were some deviations by person. The food information system completely eliminated the scrutinies of the food labels and it enabled the remarkable saving of time.

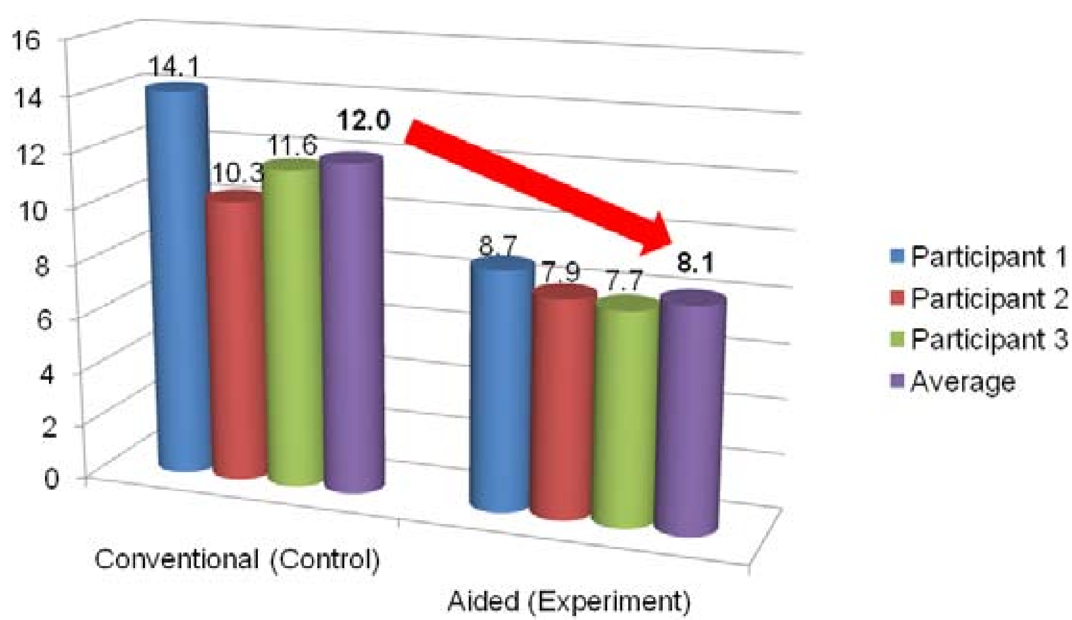
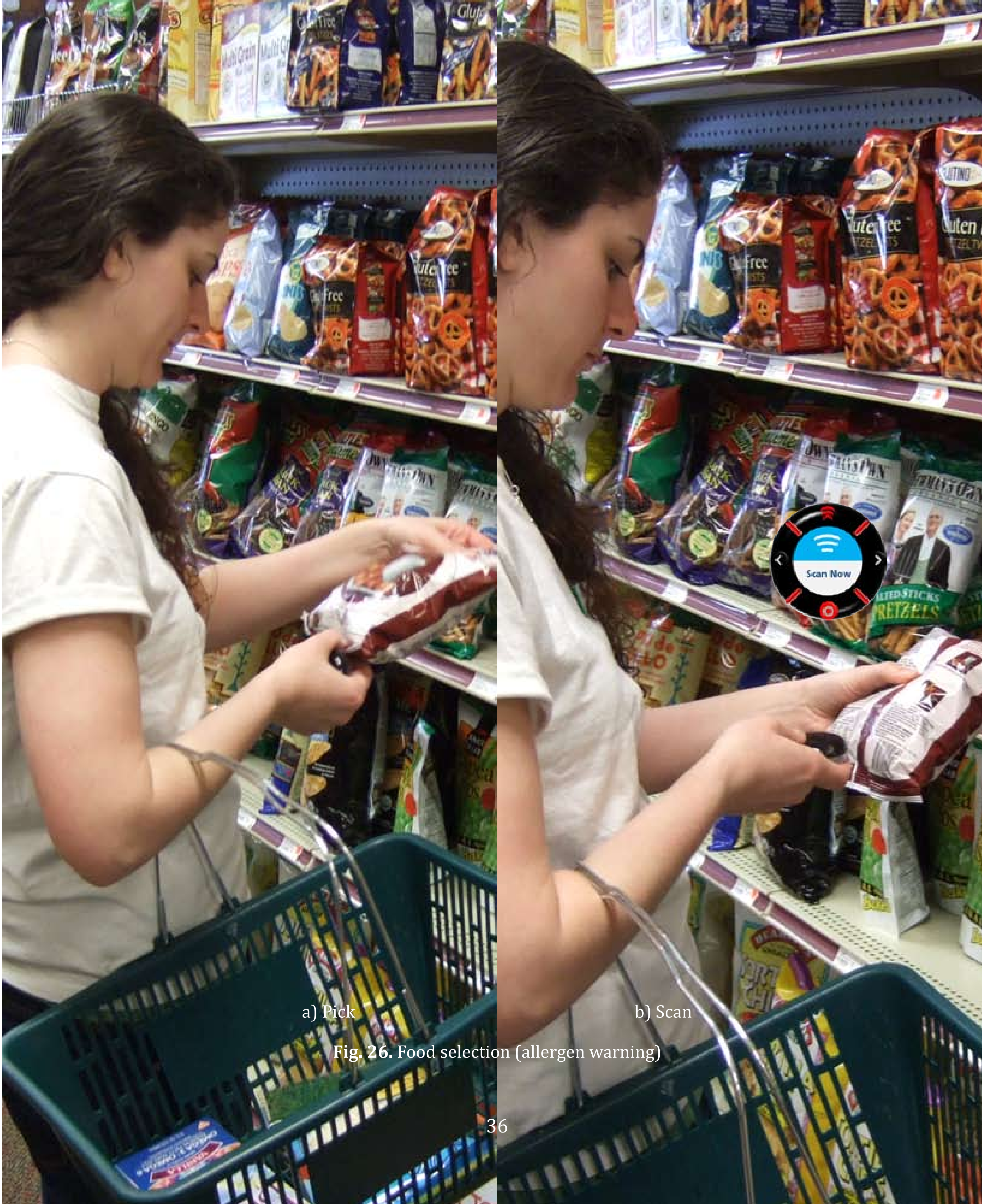


Fig. 25. Comparison of food selection processes (in minutes)

After the tests, the participants related responses and comments about their shopping experience. In the discussions, almost all of them were invigorated by the convenient and fast shopping assisted by the device and recognized potential of the food information system. They were especially impressed by the simple single-touch operation, instant warning and personalized serving size. Detailed process is illustrated in Fig. 26-28 (pages 36-40).



a) Pick b) Scan

Fig. 26. Food selection (allergen warning)

c) Warning

d) Decision

a) Pick b) Scan

Fig. 27. Food selection (changing serving sizes)

c) Serving sizes

d) Decision

Fig. 28. Food selection

4.3. Possibilities

The field tests suggested diverse possibilities of the food information system as a comprehensive tool. The promising capabilities will be dealt with in successive research.

Socialization: There are many support groups that help patients and their families, support each other and share information. The food information system can help the users socialize and facilitate creation of communities.

Globalization: The bar code system is being used worldwide, mainly based on either UPC (Universal Product Code) or EAN (European Article Numbering), and most countries have similar databases to manage domestic commodities. Therefore, global application of the system would be possible. By utilizing global food databases, it will enable the users to check virtually any food products in any country.

Diversification: The coverage of the food information system can be stretched out to other categories of products, such as health supplements and medicines. It will be a powerful tool for selections, respecting and answering individual needs for health and safety.

5

Conclusion

Food-related diseases afflict numbers of patients and incur astronomical expenses for medical care. As the situation gets worsening, the importance of food is emphasized to prevent and manage those health problems. Nutrition and ingredients facts printed on food products are the most familiar source to get information about the food. However, it is so difficult to read and understand the food labels that food buyers miss the information that may be crucial. In addition, the lack of legibility and intelligibility makes many people spend longer time in food shopping.

Responding to the problems caused by the existing food labels, this study aimed to address a new way of getting food information. To develop the design solutions, users' health conditions, food shopping experience, sources of food information and difficulties created from current food labels were analyzed from comprehensive user surveys. Utilizing the results, a food information system was developed to help the users make smart choices of food products, based on their own health conditions.

As an important part of the system, the personal device was designed to empower the users to make individual criteria, scan food products, and get customized food information from the built-in databases. The user interface was also created and embedded in the device to facilitate the user's interactions through intuitive graphics and logical structures. For maximized usability and accessibility, an interchangeable connector was attached to the personal device. Accessorizing the device to a wristband, a necklace or a clip eliminated the users' burden of remembering to bring it for food shopping. A toy-styled device for children was also included in the design process to mitigate parents' worries about their allergic children.

Field tests, conducted to evaluate the food information system, verified its usefulness for food shopping. The user-centered design of the device was favorably received by most participants and they recognized the unprecedentedly easy and fast shopping experience through the food information system. The simulation field tests proved the performance of the system, reducing up to 32% in shopping time.

Not only the targeted user group but also health care professionals showed great interest in the system. Potential applications of the system were suggested and especially utilizations for health care and nutrition management were promising. Further research will crystallize those possibilities.

Appendix I Survey Questionnaire

This survey was prepared to understand substantial needs related to food shopping and health. Please feel free to answer based on your experience in the last three years.

1. How often do you purchase food? Choose one and write your food shopping frequency.

   (   ) time(s) a week
   (   ) time(s) a month
   (   ) time(s) a quarter
   (   ) time(s) a year
   I don't know
   I don't buy food

2. If you answered any numerical frequency to Q1, how long do you normally spend for food shopping?

   (   ) hours per visit
   I don't know

3. Who do you buy food mostly for?

   For myself only
   For my family or cohabitant
   For other people only
   Other (Please specify:)

4. Do you have any health problem requiring a special diet plan?

   Yes (Please specify:)
   No

5. Does your family member(s) or cohabitant(s) have health problem requiring a special diet plan?

   Yes (Please specify:)
   No

6. Do you have any personal criteria about food? If so, please describe it freely. For example, 'No Peanuts' or 'Less fat'.

Yes (Please specify:)
No

7. Do your/your family's health issues affect your grocery shopping in any ways? If so, please describe it in detail. For example, longer shopping time or checking every food ingredient.

( )

8. How do you get information about food? Which source do you rely on more or less? Please rate each of the sources which you have used, based on its frequency of use for food selection. (Not at all/Seldom/Occasionally/Often/Always)

Doctor's advice
Peer's recommendation
Facts on food packages
Internet
Books and magazines
Commercials
Other
(Please specify:)

9. This question is about food labels PRINTED ON FOOD PACKAGES. How much are you satisfied with the information printed on food packages? Please rate your satisfaction based on each criterion below. (Very unsatisfactory/Unsatisfactory/ Tolerable/Satisfactory/Very satisfactory)

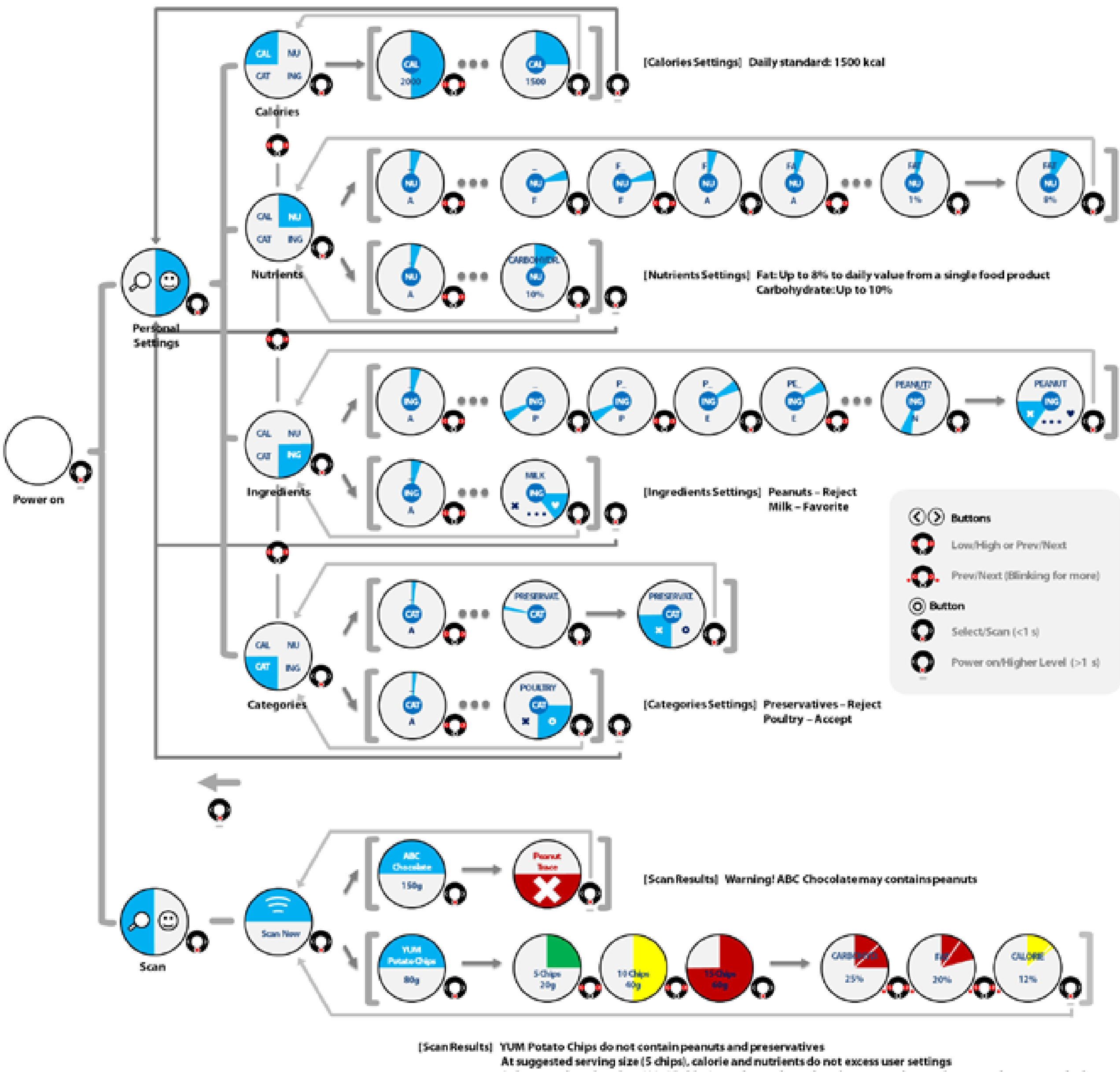
Legibility (font, size, position)
Intelligibility of the terms
Serving size, calories and units
Ingredients information
Nutrients information
Allergens information
Amount of information
Applicability to my own health issues

10. Adding to question above, please specify if you have any other issues about food labels.

(Please specify:)

11. Please specify your gender and age.

Appendix II User Interface



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