Designing Pictogram for Food Portion Size

Y.C. Liu, S.J. Lu, Y.C. Weng, and H. Su

Abstract—The objective of this paper is to investigate a new approach based on the idea of pictograms for food portion size. This approach adopts the model of the United States Pharmacopeia- Drug Information (USP-DI). The representation of each food portion size composed of three parts: frame, the connotation of dietary portion sizes and layout. To investigate users' comprehension based on this approach, two experiments were conducted, included 122 Taiwanese people, 60 male and 62 female with ages between 16 and 64 (divided into age groups of 16-30, 31-45 and 46-64). In Experiment 1, the mean correcting rate of the understanding level of food items is 48.54% (S.D.= 95.08) and the mean response time 2.89sec (S.D.=2.14). The difference on the correct rates for different age groups is significant (P*=0.00<0.05). In Experiment 2, the correcting rate of selecting the right life-size measurement aid is 65.02% (S.D.=21.31). The result showed the potential of the approach for certain food potion sizes. Issues raised for discussions including comprehension on numerous food varieties in an open environment, selection of photograph or drawing, reasons of different correcting rates for the measurement aid. This research also could be used for those interested in systematic and pictorial representation of dietary portion size information.

Keywords—Comprehension, Food Portion Size, Model of Dietary Information, Pictogram Design, USP-DI.

I. INTRODUCTION

USING images as a way of representing information could benefit to the comprehension of prescriptive instructions [1,2]. Generally, recognizing an image is easier than reading text [3]. Images, e.g., pictograms support users such as those with poor language proficiency or low educational background in comprehending the content as well as in increasing the level of understanding [4, 2].

Studies on image representation of dietary portion size information are significant. This is because food portion size is a strong environmental factor contributing to the obesity epidemic [5]. For users, a convenient and ease-to-understand description of dietary portion size is helpful to their control of dietary intake [6]. Visualization of food items and dietary aids have been used to enhance the measurement and recall of portion sizes [7,8]. One example is such as U.S. Centers for Disease Control and Prevention and National Center for Health Statistics that uses 1:1 life-size color pictures to represent the

dietary information and developed portion size measurement aids (PSMAs) [6,9]. The aids are represented in terms of glass, spoon, sack, glassware, paper box and other containers. Despite the availability of various auxiliary methods, there is no common representation used for portion sizes.

In this paper, we attempt to explore the idea of pictograms to see if the merit of USP-DI could appropriately represent food portion size, i.e., food item and portion, and support the measurement of portion size. As the research of using the idea of pictograms in portion size information is limited, we learned the ideas of pictograms from the domain of pharmaceutics that have been widely used for full and comprehensible information [10-13]. One example is USP-DI (U.S. Pharmacopoeia, Drug Information), standard black-white iconic elements [14] were developed based on drug-using habit and regulations. Those elements are easy to understand. In addition, USP-DI is highly applicable and the syntax of the elements is defined so as to represent extendable meanings [14]. These meanings are used to describe drug instructions, preventive and warning messages. Applying USP-DI to drug instructions include U.S. and the countries in Africa and Europe. The users of those images include special communities such as the elderly, children and people with low education level [13,15-18]. However, USP-DI is not always suitable for all people. Sometimes, USP-DI mode needs to be partly revised to better meet the needs of users. Relevant research [10,11] explored the influence on users' understanding level of USP-DI elements to consider the factors like cultural differences, education, age, and community.

In this paper, we first model dietary portion size information applying the idea of USP-DI, followed by two experiments to valid this model. The results, discussions and further research issues are also described.

II. PICTOGRAM REPRESENTATION

In this paper, the model of dietary information using pictograms is composed of three parts: frame, the connotation of dietary portion sizes and layout (as shown in Table 1). The definitions of each part and rules for combination used to represent portion sizes are explained as follows.

A. Frame

Frame helps to recognize the category of information, enabling users to comprehend the intention conveyed by the pictograms. Three categories are defined, following USP-DI, i.e., general, ban/warning or precaution. Information with general intention is framed with the shape of a square. This type of frame is used for definition or description of information,

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e.g., the information like food types, portions and their nutrition. Information with ban/warning intention is framed of a circle with an "X" on top of it. This is used to represent information like "no fried foods" recommending the item unsuitable for the user. Information with precaution is presented by an upside-down triangle frame. This is used to describe a potential consequence that may be occurred under a specific situation. For example, certain actions may "cause the rise of blood pressure". "The rise of blood pressure" is the consequence.

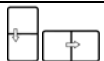### B. Dietary portion size information

The connotation of dietary portion size information consists of three main categories: food item, portion size and nutrition. Food item is a specific type of food, e.g., apple, banana, etc. Food item is dependent on relevant administrations in each country. For example, in Taiwan, Department of Health, Executive Yuan establishes types and items of food in the Food Exchange List [**19**], and all food types are categorized into six. Portion size is the amount of the food in/on a specific container or the number of a specific object to express the amount of food. Nutrition is the nutritious ingredients of food, such as protein, fat and carbohydrate. Representation of food item, portion size and nutrition is described below.

1) Food item is drawn from a 45 degree depression angle. The shape of food is simplified and the outline of it is drawn in abstract lines and presented in the color of cartoon pictograms. As the types of food are many and some of them are highly similar, if presented in the same black-white as USP-DI, the features may not be easily identified. Research has shown that colored sketches help users understand better than black-white ones [20]. The representation of food items in this paper adds colors to present various foods, excluding the background and other unwanted details and keeps the background blank.

2) Generally speaking, the unit of portion includes 'bowl,' 'cup' and 'piece'. The amount of food is established in accordance with the ratio of portions. Since USP-DI has no pictograms of portion size design, the study then creates it on the basis of relevant studies of dietary portions, taking commonly seen objects to serve as the scale to interpret the size of portion. For example, 1/3 bowls, 2 cups or 1 piece. If take a "2/3 bowl of rice" as an example, the food item is "rice", the unit of portion is a "bowl" (240 grams) and "2/3 rice" is 160 grams if calculated scientifically. It is worth noticing that the description of scientific measurement cannot make users truly understand the size or the amount. Therefore, in this research, we use common shared descriptions. For instance, apples and pears can share the same unit, while both rice and noodles can be expressed with a bowl.

3) The measurement aid is in line with the size of 'bowl,' 'cup' and 'piece'. Objects have proven to help measure and control portions of diet, such as credit card, tennis ball, finger, palm, and fist [21]. Physical features like hand and head are widely known 'body languages,' helping to interpret the pictograms [12]. Hand is used in this paper to serve as the measurement aid selecting from a number of commonly seen things. The hand is presented in the state of fully opened, while the portions of an object are piled up before the fingers, straight in line with the left and the bottom sides of the palm so as to tell the size of the portion (shown as Table 2-1). This type of representation is supposed to be reusable, emphasizing the size of certain containers and the amount of food, excluding the content of food item. The representation of portion is demonstrated in the same black-white as USP-DI. The shape and outline of bowl, cup and piece are represented in an abstract way. For example, one apple is considered as a circle. The shapes of bowl and cup are predictable, so they are presented with 2D side view. Regarding the presentation of the amount, based on the ratio of portions, it is shown with pieces equally divided by dotted lines, filling with grey blocks.

4) Nutrition, such as protein and fat, can be hard to recognize from the form of chemical composition. The abstract representation in USP-DI is seen, such as the pictograms for 'frequency in the morning', 'place for hospital', and 'movement of stirring'. The representation of each type of nutrition requires further investigation, and is not included in this paper.

TABLE I
MODELING OF PICTOGRAM REPRESENTATION FOR FOOD PORTION SIZE

Food Portion Size	Classification	Representation
Frame	General	
	Ban and Warning	
	Precaution	
Dietary portion size information	Food items, portion size, nutrition	Stylized figurative drawing that is used to convey information
Layout	Primary-Secondary or Cause-Effect Relation	
	Sequence	

C. Layout

Layout helps to express the information with a structural and sequential order. From the perspective of this model, complicated information is comprised in individual building blocks. Each building block is composed of a specific type of frame and a certain connotation located inside the frame. Same as USP-DI, the layout has three main kinds, i.e., from upper left to the middle, from left to right, and from top to bottom. When one of the two building blocks is placed in the middle and the

other in the upper left, this layout indicates the combination of portion size being the parent-child or the cause-effect relationship. Take the serving size of "3/4 cup of milk" as an example; two building blocks are the size "3/4 cup" and the food "milk". To highlight the information on the size, the building block "3/4 cup", can be placed in the middle, while "milk" can be placed in the upper left. One example of the cause-effect relationship can be 'too much carbohydrate causes the rise of blood sugar.' In this case, 'too much carbohydrate' is the cause placed in upper left, while 'causes the rise of blood sugar' is the effect placed in the middle. Information concerning the chronological order is placed from left to right or from top to bottom. For instance, when depicting the order of dining, 'drinking soup before eating rice' puts 'drinking soup' in the left (or top), while 'eating rice' in the right (or bottom).

III. EXPERIMENTS

Two experiments were planned. The first experiment was to see if the sketch representation on food item, while the second experiment was to validate portion size.

A. Subjects

The subjects of these two experiments included 122 Taiwanese people, 60 male and 62 female with ages between 16 and 64 (divided into age groups of 16-30, 31-45 and 46-64). All were senior high school graduates or above with Chinese reading and speaking ability. The influence on judgment by subjects' physical conditions was taken into consideration. All the subjects had no serious diseases. No subjects had recently suffered any injuries, engaged in weigh loss or gain, or conducted any weight training. All subjects had their meals in a regular pattern, and no subjects had drug that would affect appetite. Visually impaired subjects were excluded.

B. Experiment 1: Evaluation of the understanding level of food items

In the test of food items, a notebook computer with a 12-inch monitor was used for display, using Microsoft PowerPoint. Testers were asked to come up with the name of the 9 food items. The test results were divided into "correct" and "incorrect". Wrong answers, not knowing or no response were defined as "incorrect". Response time was defined as the duration between the display of food images and the time when testers come up with their answers.

C. Experiment 2: Measurement of Portion Size

In the test of portion size measurement, each tester was asked to look at one of the three pictograms as shown in Fig.1 These three pictograms represent the portion size information, i.e., "2/3 bowl of green bean", '3/4 glass of milk' and "1 piece of apple". Each pictogram was posted on the center of A4 size paper. The width and length of the pictogram is 12 cm with the resolution of 300 dpi. Having recognized the pictogram, the tester was asked to select the right bowl, glass, or size of the real objects from three different life-size objects. Sizes of bowl, glass, and apple were shown in Table. The results were divided

into "correct" and "incorrect". Selecting the right one was defined as 'correct', otherwise as 'incorrect'. The tester conducting the test of "two third of green bean' or 'three quarter milk' was further asked to fill the appropriate amount of green bean or milk into the selected object to represent the amount of '2/3' or '3/4'. Again, the results were defined as 'correct' and 'incorrect'. The filling amount is within 10% weight difference range is treated as 'correct'.

One piece   2/3 bowl   3/4 glass

Fig. 1 Types of Portion Size used in the experiment

IV. RESULTS

A. Experiment 1

The result of Experiment 1 is shown in Table 2 and Table 3. The mean correcting rate is 48.54% and the mean response time is 2.89 seconds. The food items with high correcting rate are D2 (90.2%), D8 (99.2%), D12 (69.7%) and D18 (77.9%), while the food items with low correcting rate are D4 (4.1%), D6 (4.9%), D10 (10.7%) and D14 (19.7%). The food items with the response time longer than 3 seconds are D6 (3.7 seconds), D10 (3.4 seconds), D4 (3.3 seconds), D16 (3.3 seconds), and D14 (3.1 seconds). The difference on the correct rates for different age groups is significant ($P^*=0.00<0.05$).

TABLE II
PARTICIPANTS' CORRECTING RATE AND RESPONSE TIME OF THE FOOD ITEMS

Food	Correcting Rate(%) mean	Response Time (Second) mean
D2 Clam	90.2%	2.7
D4 fermented soybeans	4.1%	3.3
D6 Vegetarian Chicken	4.9%	3.7
D8 Pacific saury	99.2%	1.5
D10 Tempura	10.7%	3.4
D12 Glutinous rice ball	69.7%	2.6
D14 Cucumber	19.7%	3.1
D16 Pork ribs	60.7%	3.3
D18 Steamed Bread	77.9%	2.5
Mean	48.5%	2.9

N=122

TABLE III
CORRECTING RATE AND RESPONSE TIME OF THE FOOD ITEMS IN ACCORDANCE WITH THREE AGE GROUPS

Age	16-30 (N3)		31-45(N4)		46-64(N5)	
	mean	S.D.	mean	S.D.	mean	S.D.
Correcting Rate (%)	51.6	39.5	48.6	39.0	45.3	39.9
Response Time (Second)	20.8	1.2	26.4	1.9	31.2	2.5

N3=42 , N4=40 , N5=40。 P*<0.05

B. Experiment 2

The result of Experiment 2 is shown in Table 4. The correcting rates of measuring the right 'bowl', 'glass', and 'apple' are 65.6%, 75.4%, and 54.1% respectively, while the correcting rates of filling the right amount of '2/3' and '3/4' are 82.0% and 98.4% respectively.

TABLE IV
CORRECTING RATE OF MEASUREMENT AIDS AND PORTION SIZE

	Task	Number of Correction	Correcting Rate (%)
Measurement aid	Bowl	40	65.6
	Glass	46	75.4
	Apple	33	54.1
	Mean	39.66	65.0
Portion size	2/3	50	82.0
	3/4	60	98.4
	Mean	57	93.4

V. DISCUSSIONS

A. Understanding level of food items

In this study, food items were presented based on USP-DI sketch with color mode. The results showed that mean accuracy was lower than 50% and became even lower with the increase of the age of the testers. In terms of response time, there existed an obvious difference among different age groups. The USP-DI sketch mode was used to present food varieties in this study and the real situation was also simplified to highlight the major characteristics of the objects' outward appearance. However, the color presentation of the objects couldn't be as concise representation, leading to some food items with a low understanding level and affecting users' grasp of the information. This showed that the understanding of the sketches was affected by the explicitness of the information presentation [4]. The past studies suggested that the presentation of the information details was necessary for the content of information to be clearly distinguished [2].

Although the use of USP-DI drawing mode for some food items achieved a low understanding level, it can be improved if the characteristics of food can be expressly presented. Take clams and Pacific saury for example, they were presented using USP-DI drawing mode, but the effect of information communication was not affected. A better understanding could be achieved through the repeated revisions of designs. In related studies such as those conducted by Mansoor & Dowse [10], the design of sketches was repeatedly modified, restrained and tested to make the sketches better understood. In terms of the explicit presentation of information on dietary education, the traits of food's outward appearance are the key factor to a better understanding. However, the appearances of some food categories cannot be used as reference. For example, vegetarian chicken which is made of soybean does not look like soybean at all, and tempura which is made of fish paste does not have the appearance of a fish, and other food items that emphasize their nutritious content such as fresh low-fat milk that stresses its nutrition characteristic of being "low-fat" but its nutrition content cannot be understood through its outward appearance. Accordingly, the image presentation of this kind of food should include the information on the characteristics of food. Moreover, the existence of numerous food varieties makes it difficult for people to know every kind of food, which will contribute to the results of either not knowing or no response. This kind of temporary no response will result in the disconnection between their knowledge and information content, and further lead to incorrectness.

B. Photograph vs. Drawing

As to whether it should be presented with photograph or drawing, the research on the use of drug instruction showed an obvious difference from those on the use of sketch presentation for nutrition education. Most of the sketches for drug instructions are based on drawing mode and use cartoon-style and abstract lines [22,23]. Readance & Moore [20] explored the level of understanding through the image-assisted reading suggested that sketch drawings help readers' understanding more than colored drawings or photographs. Moll [24] found that cartoon-style drawings achieved the highest understanding degree, followed by line sketches and photographs whose effect was the worst. Generally speaking, the use of sketch mode for drug use can attract users' attention and increase their fondness and further strengthen users' intention to change their behavior. However, diet-related researches produced different results which suggested that the use of photographs increased people's understanding of information on food and achieved food control effects [6-9]. The possible reasons might be that people were easy to be confused by numerous food varieties and their similar appearance regardless of their different colors, and the situation of their use was in a limited environment. It is different from USP-DI's description of content in a drug package, in which the pharmaceutical categories are limited and the drug images can be drawn using dots, lines and planes or with added lines and drawing style [25] and the use of black-white lines is sufficient to distinguish the differences. Its advantages include a broader content coverage by the images, a fewer number of image designs and highly repeatable use. Readance & Moore [20] indicated that line sketches could achieve a higher users' understanding level than colored drawings or photographs. To expressly present the content of information, it is necessary to explore the influence on users' understanding by the way in which images are presented. Be it presented with photographs or drawings, a good image presentation needs to be able to strengthen the expression of information content in order for users to achieve their best understanding. Related studies suggested that the understanding of the information content presented with photographs of real objects wouldn't be affected by age difference. Generally, the physical and mental degeneration caused by aging will lead to a poor ability to understand and response [26,27].

C. The exploration of the level of understanding on portion size

The understanding of dietary portion size needs to take into consideration the relations among size (big or small), scale (hand) and actual portion size (objects for comparison). Users need to convert the sketch scale into real size before they can calculate the actual portion size. The 2D heights and widths of bowls, glasses and apples were used for the food portion size calculation in this study. The length and width of hands was also used to serve as the basis for the measurement of the height and width of a dietary portion. The appearances of the glasses used in this study were of straight lines, and had small variations in width but had bigger differences in height to allow the judgment of glass size by comparing only their heights, which means the users only needed to make a 1-dimensional comparison. On the other hand, the bowls used in this study had small difference in their heights but with bigger variations in their widths. But the curve of the bowls would affect the judgment of their widths. As a result, the use of bowls achieved a lower level of understanding than glasses. However, as apple is a kind of natural food with a curved surface, the accurate measurement of its height and width is more difficult because of its appearance.

Due to the abstract (round shape) presentation, the shape of a dietary portion and the appearance of food categories might be similar to but not fully conform to those of apples. Besides, more dimensions needed to be taken into account such as height, width and the change of curves. The presentation of a dietary portion needs to consider the universal expression of food's shape. Although, the scale of hand which is convenient was used in this study, it can cause measurement errors because the hands of users of different physiques were also different in size.

The judgment of portion size needs to be combined with the size of actual food. For some kind of food, users are required to make choices in an open environment where it is impossible for them to access to the food with the appearance and size that fully conform to the requirements of dietary education. Take apples for example, apples that grow naturally cannot be controlled to be of the same size. Only apples of specific size can be selected. Therefore, it is impracticable to require every apple to be of exact size. Besides, the setting of a permissible scope for size can enhance the understanding level of the image design for portion size. Take the selection among apples of 3 different sizes for example; a permissible variation scope needs to be determined before the size difference can be distinguished because a test can be meaningful only when it is conducted on the understanding level of the apple sizes of different ranges. In short, the image design of portion size needs to consider the universalism of appearance, the selection of scale, the visual effect of the key portion size's presentation on the scale and the comparison of the influence of size variation scope on users' understanding level.

In terms of the grasp of portion, the results of this study showed a high understanding level mainly because the image presentation used in this study was based on the expression of multiple. The amount of food was expressed by multiplying or dividing a portion. It was found that this kind of presentation can achieve an high understanding level. Besides, all the subjects in this study were graduates of senior high schools or above and were equipped with the ability of multiplication calculation and the knowledge on quantity judgment. This showed that this kind of representation for the expression of amount was workable to this community.

D. The investigating the potential use of this image design

To consider the flexibility of this approach, unlike photographs that make it impossible to divide the information content into elements for repeated use. Every portion size or food item needs to be retaken. However, within this approach, for example, the elements, such as 'bowl', 'glass', etc can be repeatedly used. As for expandability, it is difficult to use photographs to incorporate other dietary information, for example the portions size information and the cooking methods (such as blanching). However, within this approach, it is possible to make the information systematically modularized, which expanded information could be expressed in this approach.

VI. CONCLUSIONS

The study proposed an innovative approach with the use of pictograms representing food portion size information. In this paper, an initial investigation was conducted to see if this approach is appropriate as well as in search of potential issues. Each pictogram, similar to USP-DI, is divided into elements in terms of frame, dietary portion size information, and layout. Elements of pictogram were defined in this paper, and two experiments related to comprehension and portion size measurement were conducted. The results from the experiments showed the potential of this approach. This research also could be used for experts or researchers interested in systematic and pictorial representation of dietary portion size information. However, there are still many topics worthwhile exploring. Suggestions are made below for the future research.

A. Investigation of the design of food item and portion size and the layout

Dietary portion size information based on the idea of USP-DI pictograms is yet to be explored. One influential factor that affects the comprehension of dietary portion size information would include: whether the representation of each food item encapsulates distinguishing features; selecting appropriate level of representation, e.g., photographs or sketches; design of portion size including appearance, proportion and display; the choice of comparative objects (such as a hand or a credit card) .

This study only focused on the representation of food item and portion size. How will the placement of information affect users' understanding of the information? Should the portion size information be placed at upper left or in the middle of the pictogram? Research showed people tend to pay their attention first on color then on shape [28,29,30]. Will full-color

presentation of food items affect the comprehension and lead to their ignorance of the implications on frame and portion size? To comprehend portion size information, the influencing factors should be taken into account.

B. The evaluation of other criteria

Currently, this research was conducted only on understanding level of the information. It was also suggested that various criteria be included in the future. Possible evaluation factors would include attention, comprehension, judgment, the change of attitude and belief, and the resulting change of behavior [4]. Related studies such as those conducted by McDermott [22] and Delp & Jones [23] can be further investigated. When including with the culture of a specific community, pictograms could provide better influence on users' understanding level [29,35]. Currently, no specific communities have been conducted. In the future, the needs of specific communities' cultures can be included, and further exploration should be conducted on the effectiveness of this approach.

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