Designing Product Listing Pages on e-Commerce Websites:
An Examination of Presentation Mode and Information Format

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Abstract

Web interface design is of enduring interest to researchers as online shopping on the Internet continues to grow. Prior research has shown that the design of product listing pages, where information on multiple products are displayed together to allow further exploration of any of them, has a great influence on the traffic and sales volume on a website. In this paper, we focus on two design features, presentation mode and information format, and examine their impact on users' interaction with websites. An experiment was conducted to compare text-only versus image-text presentation modes, based on the dual coding theory, and list versus array information formats, based on the proximity compatibility principle. In general, the findings support the application of the dual coding theory and the proximity compatibility principle to the e-commerce domain. Specifically, the image-text presentation mode and the list information format were found to outperform the text-only presentation mode and the array information format respectively in terms of shorter information search time, better recall of brand names and product images, and more positive attitudes towards the screen design and using the website. Given the same information content, the spatial arrangement of products and the hierarchical placement of images can make a difference to users' online shopping performance and attitudes.

KEYWORDS: human-computer interaction, e-commerce, experiment, presentation mode, information format, dual coding theory, proximity compatibility principle, Web interface design.

1. Introduction

Despite the burst of the dot.com bubble, online shopping continues to grow (Forrester, 2002). Previous research has identified a number of factors that can potentially influence users' online shopping behavior, including Web interface design, products and services, page loading speed, and transaction security (Dholakia and Rego, 1998; Gehrke and Turban, 1999; Hoque and Lohse, 1999). Among these factors, the Web interface design is consistently mentioned as critical to the success of electronic commerce. Of special interest is the design of product listing pages on commercial websites, where a number of products are displayed together to allow further exploration of any of them (Lohse and Spiller, 1998a; 1998b). Product listing pages are relevant to all commercial websites selling products because despite the variety in products sold online, the design of product listing pages is relatively consistent, which usually contain the names of the products, brand names, prices, and often images of the products. According to Lohse and Spiller (1998a; 1998b), the design of product listing pages explains more than half of the variance in monthly sales on commercial websites. Despite the importance of the design of product listing pages, there is a lack of focused research on its specific design features.

A major issue in designing product listing pages is how to attract online users' attention (Davenport and Beck, 2001). Cognitive psychologists generally agree that human attention is a limited resource that can be directed either voluntarily or involuntarily in the visual field (Bravo and Nakayama, 1992; Pashler, 1998; Wickens and Hollands, 2000). Deployment of voluntary attention depends on users' knowledge of the visual field and the search target, which is considered as a top-down process following some inner search plans. On the other hand, human attention can be guided involuntarily to visual stimulus in the visual field, which is considered as a bottom-up process (Yantis, 1993). Under most circumstances, the distribution of attention reflects a combination of both processes, with one process dominating the other depending on

the situation. While it is difficult to control users' knowledge of the visual field or the search target, commercial websites can influence users' bottom-up process by varying the interface design features.

Involuntary attention can be driven by visual stimulus, such as color, shape, size, motion, and spatial arrangement (Treisman and Gelade, 1980; Wickens and Hollands, 2000; Wolfe, 1994). On commercial websites, certain design characteristics, such as color and shape, are largely determined by the nature of the products that are sold on the website. However, other design characteristics, such as the spatial arrangement of products on the webpages, and the placement of product attribute information in the navigational structure of the website, are largely determined by the website designers. Therefore, research on the later category of design features will be useful to guide the design of commercial websites. In this study, we examined two design features of product listing pages, i.e., presentation mode and information format. Presentation mode addresses how easily product information can be comprehended to facilitate the shopping process, and the two major modes of presentation on the Web are visual (*image*) and verbal (*text*) (Chau et al., 2000). Information format is defined as the organization of information about the available products and their attributes (Cooper-Martin, 1993). Two popular information formats widely available on commercial websites are: the *list* information format and the *array* information format. The two information formats differ in their spatial arrangement of product information on the webpages. Our research question is: Given the same information content (e.g., same number of products, same size and color of product images) on product listing pages, how will the presentation mode and information format affect users' online shopping performance and attitudes?

The dual coding theory (Paivio, 1990) and the proximity compatibility principle (Wickens and Andre, 1990) from the cognitive psychology literature were adopted to investigate

the effects of presentation mode and information format respectively. An experiment was conducted to examine the effects of image-text versus text-only presentation mode, and the list versus array information format on users' online shopping performance and attitudes. The findings from this research will provide useful insights into the design of product listing pages, and help online retailers to make decisions concerning the spatial arrangement of products on webpages and the hierarchical placement of images on websites.

2. Theoretical Framework

2.1. Dual Coding Theory (DCT)¹

The dual coding theory (Paivio, 1990) proposes that there are two types of phenomena handled by separate cognitive subsystems: one specializes in the representation and processing of nonverbal (visual) information while the other specializes in dealing with verbal (text) information. Nonverbal processes, such as recognizing a picture or an object, normally involve parallel or synchronous processing in which all available information is processed simultaneously up to some informational limit. On the other hand, textual information is a major type of information processed by the verbal system, which involves sequential processing following a certain direction. In general, the parallel processing in the visual system tends to facilitate quicker information scanning and decoding than the sequential processing in the verbal system.

¹ DCT has received considerable empirical support in a variety of research areas, including marketing (e.g., Unnava and Burnkrant, 1991), education (e.g., Mayer and Sims, 1994), and information systems (e.g., Malaga, 2000). However, there are alternative theories concerning human processing and memory of visual and verbal information, such as the Propositional Schema Theory (van Dijk and Kintsch, 1983) and the imagery effects (Roediger and Weldon (1987). Paivio (1991) summarized these arguments and provided discussion on the validity of DCT despite of the alternative theories. As Rieber (1994) has noted, although the debate over which theory represents actual human cognition may never be resolved, DCT provides a useful theoretical framework to conduct cognitive research.

Both the verbal and visual systems are functionally independent, as either system can be activated without the other, and functionally interconnected, as one system can initiate activity in the other. The DCT predicts that there are three distinct levels of processing that occur within or between the verbal and visual systems: representational, referential, and associative. Representational processing refers to the relatively direct activation of the verbal or visual system by text or imagery stimuli respectively. Referential processing describes the connection between the verbal and visual systems, and associative processing depicts the activation of information units within either of the systems.

According to the DCT, imagery stimuli are more likely to be coded both visually and verbally; while texts are less likely to be stored visually. Therefore, the dual coding of images makes them easier to be remembered, resulting in the “picture superiority effect”, i.e., the superior memory of pictures and images over words. The greater number of memory codes for images acts as multiple retrieval routes to those images, and therefore enhances information retention and recall. On the other hand, the activation of nonverbal presentation is a function of the concreteness of the verbal stimuli. For example, it is much easier to picture a “dog” in one’s mind than “friendship”. Concrete concepts are easier for people to visualize simply because they refer to tangible objects that have a physical form (Rieber, 1994).

2.2. Proximity Compatibility Principle (PCP)

The proximity compatibility principle (Barnett and Wickens, 1988; Wickens and Andre, 1990; Wickens and Carswell, 1995) describes how the compatibility of the task characteristics with the display proximity can affect task performance. It differentiates between two types of proximity: display proximity and processing proximity. Display proximity defines how close together two display units lie in the user’s perceptual space. Thus, two display units will be in closer proximity if they are spatially close together, share the same color, or use the same coding.

Processing proximity defines the extent to which two or more information units are used for the same task. If the information units must be integrated (e.g., comparison) in a task then they have high processing proximity; if they should be processed independently then the processing proximity is low.

The PCP proposes that display proximity should match the processing proximity, i.e., high (low) processing proximity tasks should have high (low) display proximity. Spatial closeness, commonality of color, and similar coding of information units generally make their comparison and integration easier because of the decrease in visual search cost and search time. A user's visual search effort depends not only on eye and head movements but also on the internal movement of attention (Van der Heijden, 1992). For example, two information units within a few degrees of visual angle can often be scanned without eye movements. Also, it is easier to read a sequence of digits or words than to read a sequence of mixed digits and words, because there is less need for internal movement of attention. On the other hand, a low display proximity makes it easier for users to focus on a particular information unit, which is beneficial for tasks with low processing proximity. The predictions of the PCP have been examined and generally supported in many different contexts (e.g., Goettl et al., 1991; Liu and Wickens, 1992; Mori and Hayashi, 1995).

3. Hypotheses Development

3.1. Independent Variables

We assume a two-layer hierarchy in presenting product information. The first layer is the product listing pages where a number of products are listed with general information (such as brand names and price). The second layer is the detailed product information page, where the detailed attributes of one particular brand of product are presented. Online users can click on any of the

products on the listing pages, and be directed to the detailed information page of that product. We choose this hierarchy for two reasons. First, major commercial websites adopt similar hierarchies to present multiple product information (e.g., shopping.yahoo.com, www.amazon.com). Second, presenting all attributes for all the products on the listing pages is likely to clutter the webpage. We then vary the presentation mode and the information format on the product listing pages.

Presentation Mode: Image-text versus Text-only

While product images are widely used on commercial websites to enable users to view the products, text versions of product listings can also be found on major websites to allow display of more products on a page and reduce time to download the page. Meanwhile, detailed product information, including larger product images, are normally included on the detailed product information pages to satisfy users' need to examine the characteristics of products. In this study, the image-text presentation mode refers to the design of product listing pages that contains both images and brand names; while the text-only presentation mode refers to the design that contains only brand names on the product listing pages. In both conditions, product images are still available on the detailed product information page. While both presentation modes are commonly available on commercial websites, there is little empirical research that examines their effects on users' online shopping performance.

Information Format: List versus Array

There are two common formats to organize multiple products on a product listing page. The first format is to display only one product on each row, which we call the list information format. The second format is to display more than one product on each row, which we refer to as the array information format. Note that while the list and array information formats are widely used by major commercial websites (e.g. Yahoo and Walmart), there are a variety of other information

formats available, such as iconic presentations in irregular positions and presentation of products in context. Nevertheless, the findings concerning list and array information formats will be relevant to many commercial websites.

3.2. Dependent Variables

Prior research suggests that users shop online for both goal-oriented and experiential reasons (Babin et al., 1994; Hoffman and Novak, 1996). For goal-oriented behavior, performance measures such as efficiency and effectiveness are important. We use information search time to represent efficiency, and recall of brand names and images to denote effectiveness. Information search time is defined as the time taken to examine the product listing pages before making a product selection; while effectiveness is defined as the degree to which users can recall product information (both product images and brand names) available on the website. To evaluate experiential behavior, users' perception of the screen design and their attitude towards using the website are critical to future purchase behavior from that website. Attitude towards the screen design is defined as users' perception of the favorableness of the website's screen design; while attitude towards using the website is defined as the users' perception of their willingness to use the website for future purchases. These measures are also consistent with the website design framework proposed by Singh and Dalal (1999) relating to how well a website satisfies users' information goals and generates positive attitudes among users.

3.3. Hypotheses

Presentation Mode

The major activity that users conduct on the product listing pages is to examine and compare the products. As the detailed product information is kept on another webpage, users will need to go back and forth between a product listing page and its related detailed information pages to

compare product attributes. Based on the dual coding theory, we propose that there will be differences in terms of information search time, recall of brand names, and recall of product images between the image-text and text-only presentation modes.

First, according to the DCT, images involve parallel processing, which is faster and lighter on memory load than the sequential processing of texts. Hence, when product images are provided on the listing page, users' processing of the imagery information is likely to be faster than their processing of the textual information of brand names. This will result in shorter information search time for the image-text presentation mode as compared to the text-only presentation mode (H1a). Second, brand names are normally non-concrete words that are difficult to visualize. This is especially true when they are unfamiliar brand names (for familiar brand names, such as Coca-Cola, users might have already built an inner relationship between the image of the product and the brand name). Under such conditions, dual coding is more likely to occur when both brand names and product images are presented than when only the brand names are presented. Therefore, in the text-only condition, there will be limited dual coding between the brand names and the product images because the images are only available on the detailed information pages. Also, most of the comparison work will be carried out on the product listing pages, where only brand names are available, making it difficult to conduct associative processing between the images and the brand names. In the image-text condition, more dual coding is likely to occur as both images and brand names are available on the product listing pages. This will result in better recall of both product images and brand names in the image-text presentation mode. Therefore, we expect the recall of images (H2a) and brand names (H3a) to be higher in the image-text presentation mode than in the text-only presentation mode.

H1a. Information search time will be shorter in the image-text presentation mode than in the text-only presentation mode.

H2a. Recall of product images will be higher in the image-text presentation mode than in the text-only presentation mode.

H3a. Recall of brand names will be higher in the image-text presentation mode than in the text-only presentation mode.

According to the DCT, images can be more readily processed and encoded than texts. When users are examining the product listing pages for a potential item to purchase, product images make it easier for them to track which products they have examined previously, and subsequently reduce the number of unnecessary revisits of detailed product information pages. Also, a Web interface with images appears to be more vivid and increases the level of concreteness that is crucial to online shopping. Therefore, we expect users' attitude towards the screen design to be more positive in the image-text presentation mode than in the text-only presentation mode (H4a). Finally, as users are likely to feel more comfortable with the screen design and find it more convenient to conduct shopping when product images are present, their attitudes towards using the website are expected to be more positive in the image-text presentation mode than in the text-only presentation mode (H5a).

H4a. Users' attitude towards the screen design will be more positive in the image-text presentation mode than in the text-only presentation mode.

H5a. Users' attitude towards using the website will be more positive in the image-text presentation mode than in the text-only presentation mode.

Information Format

The task of comparing different products on the product listing pages is of a high processing proximity. According to the proximity compatibility principle, better performance can be expected if a high display proximity design is provided for high processing proximity tasks. A major difference between the list and the array information formats is the spatial proximity among the products. Assuming a 12cm by 18cm display space, the products in the list information format has an average distance of 4.67cm between each other, while those in the

array information format has an average distance of 8.45cm (see Appendix A). Changing the screen size will not affect the relative display proximity of these two information formats. The list format consistently has higher display proximity than the array information format.

According to the PCP, a high display proximity is better at supporting high processing proximity tasks because it can save users' effort in moving their eyes, heads, or internal attention. For example, in the list information format, users can possibly examine two consecutive products without moving their eyes or heads; while in the array information format, users can only examine one product at a time before moving their eye fixation to another product². All these movements will cost not only effort, but also time. The time it takes to move one's eyes or head may be tiny, but when multiple comparisons among products are carried out, the time difference will be amplified. Therefore, we expect the information search time to be shorter in the list than in the array information format (H1b). Moreover, a high display proximity will reduce users' need to switch internal attention, which lowers the cognitive load. This will leave the users with more attentional resources to spend on processing the product information. Therefore, we expect the recall of both product images (H2b) and brand names (H3b) to be higher in the list than in the array information format.

H1b. Information search time will be shorter in the list information format than in the array information format.

H2b. Recall of product images will be higher in the list information format than in the array information format.

H3b. Recall of brand names will be higher in the list information format than in the array information format.

² This is consistent with the visual angle analysis. If assuming a 45~50cm average viewing distance of users looking at a computer monitor (Cakir et al., 1980), the optimal visual angle of 5 degree (Tullis, 1983) will be translated into an area of 19.7~21.5cm diameter. Therefore, according to the calculations in Appendix A, users can comfortably have two products in the optimal visual angle in the list information format, while it will be very difficult to cover more than one product in the array information format.

The PCP suggests that when the display proximity matches the processing proximity of the task, users can perform the task more effortlessly. Assuming that users prefer a screen design that allows them to conduct more efficient information search with less mental effort, we expect that users will prefer the screen design with the list information format to that of the array information format. Hence, users' attitude towards the screen design will be more positive in the list information format than in the array information format (H4b). Similarly, everything else being equal, a website design that is more conducive to users' tasks will generate more positive attitude among users and increase their willingness to revisit the website. Therefore, we expect that users' attitude towards using the website will be more positive in the list than in the array information format (H5b). The hypotheses are summarized in Table 1.

H4b. Users' attitude towards the screen design will be more positive in the list information format than in the array information format.

H5b. Users' attitude towards using the website will be more positive in the list information format than in the array information format.

[Insert Table 1]

4. Research Methodology

4.1. Pretest – Stimulus Preparation

Grocery products were chosen for the experiment as they are familiar to most people including the subjects. Moreover, similarity among the product categories favors the *Latin Square* design (Kirk, 1995) that we used to balance the order of shopping trips and brands presentation.

The marketing literature suggests that product class knowledge, brand name, and price can influence users' information searching and shopping behavior (Brucks, 1985; Dodds et al., 1991). Therefore, a pretest was conducted on 29 subjects to select the stimulus of the main experiment. 14 grocery product categories with 15 brands under each category were presented to the subjects. To control for product class knowledge, the subjects were asked to rate their

familiarity with the 14 product categories. 6 product categories that are at similar level of familiarity to the subjects were selected for the main experiment (i.e., cookies, boxed chocolate, toothpaste, facial tissue, distilled water, and orange juice). All the brand names were either fakes or based on brand names in foreign countries from where the experiment was conducted in order to remove the brand name effect. The subjects were asked whether they had heard of these brand names. Based on their responses, 6 brand names were selected for each product category.

After the product categories and brand names were selected, other attributes of each brand of product were created by referring to the Consumer Reports in the U.S. and a similar type of local magazine. Price was controlled at $\pm 5\%$ within each product category. Product images were captured on the Internet and modified by Photoshop 5.0 to replace the original brand name or logo with the fake or foreign brand names derived from the pretest.

4.2. Pilot Study

An online grocery shopping system, written in ASP and Java, was developed specifically for this study. It was installed on a Windows2000 server in the same local area network as the PCs in the laboratory to ensure a consistent high network speed for all subjects. All the subjects accessed the system using the same Internet browser (i.e., Internet Explorer 5.5). Twenty-four subjects (not included in the main experiment) from the same subject pool were asked to shop on the experiment website and describe what they like or dislike about the screen design through an open-ended question. The purpose of the pilot study is two-fold. First, it tested various aspects of the experiment system, including page loading speed, reliability, and whether the design of the webpages is easy to understand and follow. Feedbacks from the subjects were used to fine-tune the design of the website. Second, based on the subjects' responses to the open-ended question, we developed a three-item instrument to measure users' attitude towards the screen design.

Following the guidelines by Ajzen and Fishbein (1980), the three most frequently mentioned terms in the answers were selected in constructing the items (see Appendix B).

4.3. Experiment Website

The presentation mode was manipulated on the product listing pages. Subjects in the image-text condition will see product images along with their brand names (see Figures 1a and 1b), while subjects in the text-only condition will see the brand names only (see Figures 1c and 1d). A detailed product information page, containing brand names, product images, and more attributes of a particular brand, was displayed when the subjects clicked on a brand name (see Figure 1e). Two information formats, *list* and *array*, were used on the product listing pages. In the list format, six brands were organized in a top-down manner, with only one brand on each row (see Figures 1a and 1c). In the array format, the brands were organized in blocks with three brands on each row (see Figures 1b and 1d). The detailed product information pages are the same across different presentation modes and information formats. Product information, font size, image size, and color scheme were held constant across the experimental conditions.

[Insert Figures 1a, 1b, 1c, 1d, and 1e]

4.4. Experiment Procedure

We employed a 2×2 between-subject full-factorial design varying presentation mode and information format. A total of 107 business undergraduate students from a major university in Hong Kong were recruited for the experiment. Participation in the study was voluntary. As an incentive, the subjects were paid US\$13 each for their participation. 4 experiment sessions were conducted in a laboratory with 60 identical Pentium III PCs connected to the Internet. The subjects were randomly assigned to each of the four experimental conditions (see Table 2).

[Insert Table 2]

At the start of each experiment session, the subjects were informed that all the instructions were provided online and that they should read the instructions carefully and complete the experiment individually. First, subjects entered their demographic information online. Next, a cover story was provided that an international company was intending to market its products online and had developed a prototype website. The subjects were asked to shop at their own pace on the website based on their personal preference. No time constraint was given. A trial shopping trip of a product category (other than the six in the main experiment) was provided before the actual shopping trip to familiarize subjects with the website and the shopping process. After that, subjects took part in six consecutive shopping trips, in which they were required to browse the products and purchase one brand in each of the six product categories. Six brands of each product category were presented in either list or array format, and either with or without product images on the listing pages. Both the order of the shopping trips and the order of the brands within each product category were randomized among subjects following the *Latin Square* design. The subjects could click on a brand name (images were not clickable) to retrieve detailed product information, including brand name, unit price, and other product attributes. A log file was generated to store the subjects' click stream data. At the end of the shopping trips, the subjects completed a post-session questionnaire containing the perception measures. This was followed by the tasks to recall brand names and images (so that the completion of the questionnaire served as a filter task before the recall). Finally, the subjects were debriefed. All experiment sessions were administrated by the same experimenter who followed a standard protocol.

Information search time was measured as the average viewing time (in seconds) of the product listing pages across the six product categories and was calculated from the subjects' computer log. Recall of brand names was measured by presenting the subjects with twelve brand

names (six valid brands and six invalid brands for each product category), and asking them to identify the brand names that they had previously seen during their shopping trips. The twelve brand names within each product category were organized together in a random order and presented in a 2-column by 6-rows table³. The overall score for recall of brand names was calculated by counting the number of correct identifications in each product category and then taking the average. Recall of images was measured afterwards in a similar way.

Perception measures were included in the post-session questionnaire (see Appendix B). Attitude towards the screen design was assessed by the 3-item instrument derived from the pilot study. Following Taylor and Todd (1995), attitude towards using the website was measured by two items with paired anchors of like/dislike and pleasant/unpleasant. Factor analysis of the two multiple-item constructs was conducted. Both constructs demonstrated adequate reliability and construct validity (see Table 3). Cronbach alpha was 0.81 for attitude towards the screen design, and 0.77 for attitude towards using the website, both of which were higher than the recommended 0.7 threshold (Nunnally, 1978). Factor loadings on their intended constructs were all above 0.70, with no cross-loadings bigger than 0.20. The scores on the items of each variable were averaged for further analysis⁴.

[Insert Table 3]

5. Data Analysis

5.1. Demographics

The average age of the subjects was 20.4 years and 63% were female. The subjects were business undergraduates, with 27% in their first year, 40% in their second year, and 33% in their third year of study. On average, the subjects have 5.6 years of experience using a personal

³ This format is different from both the 1-by-6 list format and the 3-by-2 array format, so as to minimize the confounding effect between the cueing format and the experiment conditions.

⁴ When weighted averages based on factor loadings were used, the hypotheses testing results remained unchanged.

computer, and 3.4 years of experience using the Internet. A majority of the subjects (81.3%) do not have online shopping experience at the time of the experiment.

5.2. Manipulation and Control Checks

On average, the subjects made 7.36 clicks on the product listing pages during each shopping trip, indicating that the subjects were examining and comparing product information before making their purchase decision. We also collected data on the degrees to which a subject based his/her purchase decision on the prices or the brand names of the products with two 10-point Likert scale questions. There was no evidence that the subjects' choices of brands were influenced by either the prices or the brand names of the products in the experiment. Together with the fact that all other factors, including the font face, font size, and background, were kept constant across all the experimental conditions, we are confident that the results obtained in this study were due to the manipulation of the presentation mode and the information format.

We performed control checks on subjects' experience with personal computers, the Internet, and online shopping. The results suggest that the random assignment of the subjects to the four experimental conditions was successful. There were no significant differences in experience with personal computers ($F=0.126$, $p=0.944$), the Internet ($F=0.760$, $p=0.519$), and online shopping ($F=1.552$, $p=0.206$) among the four experimental groups. The correlations of these three variables with the dependent variables were also examined. There were no significant correlations, indicating that the subjects' experience with personal computers, the Internet, and online shopping did not affect the dependent variables under investigation.

5.3. Hypotheses Testing

A MANOVA test involving all independent and dependent variables was performed. There were significant main effects for both presentation mode ($F(5,99)=14.51$, $p=0.000$) and information format ($F(5,99)=3.615$, $p=0.005$), while the interaction term was not significant ($F(5,99)=0.287$,

$p=0.919$). Therefore, we could proceed to analyze the results for each of the dependent variables. Tables 4 and 5 present the means and standard deviations of the dependent variables, and summarize the hypotheses testing results for the main effects of presentation mode and information format respectively.

The main effects of both presentation mode ($F=56.775$, $p=0.000$) and information format ($F=5.555$, $p=0.020$) on information search time were significant, supporting hypotheses H1a and H1b. The subjects spent significantly less time when images were available and when the product listing page was organized in the list format. Significantly better recall of images was found in the image-text presentation mode ($F=5.125$, $p=0.026$), supporting hypothesis H2a. However, the image-text presentation mode did not lead to better recall of brand names than the text-only presentation mode, rejecting hypothesis H3a. Recall of both the images ($F=4.582$, $p=0.035$) and the brand names ($F=7.672$, $p=0.007$) were better in the list than in the array information format. Therefore, hypotheses H2b and H3b were supported. Further analysis showed that consistent with the picture superiority effect, the overall recall of images was better than the overall recall of brand names ($t=9.750$, $p=0.000$). In addition, there was no significant difference in the viewing time of the detailed product information pages across experimental conditions ($F=0.254$, $p=0.859$).

[Insert Tables 4 and 5]

Hypotheses testing results on the perception measures were mixed. The image-text presentation mode was rated higher than the text-only presentation mode on both attitude towards the screen design ($F=12.451$, $p=0.001$), and attitude towards using the website ($F=8.976$, $p=0.003$), supporting hypothesis H4a and H5a. However, the subjects' attitude towards the screen design did not differ between the list and array information formats ($F=0.617$, $p=0.434$), rejecting hypothesis H4b. Interestingly, the subjects did hold more positive attitude towards

using the website with the list rather than the array information format ($F=5.749$, $p=0.018$). Therefore, hypothesis H5b was supported.

6. Discussion

In general, the findings suggest that given the same information content, varying the presentation mode or the information format of the website design can significantly influence users' online shopping performance and attitudes. Specifically, providing product images together with the brand names on the product listing pages is more efficient and effective than just displaying the brand names alone. Also, organizing the brands of products in a list information format can better support users' online shopping performance.

6.1. The DCT and Presentation Mode

The dual coding theory has been applied successfully to understand the effectiveness of verbal versus imagery presentation modes in a wide range of contexts, including computer assisted learning (Lalley, 1998), printed advertisements (Unnava and Burnkrant, 1991), individual creativity support systems (Malaga, 2000), and decision support systems (Umanath et al., 1990). It has also been applied in the e-commerce domain to investigate the effects of image versus text presentation modes in facilitating users' online search for a specific item (Chau, et al., 2000). Specifically, images were found to decrease the time taken to search for familiar target brand names, but not for unfamiliar target brand names. A plausible explanation given by the authors was that for unfamiliar brand names, users might not have a good idea of what the items look like. Moreover, as the search target was provided in text mode, users are likely to look at text information to locate the target brands, which diminishes the effect of images. In our study, however, images were found to support more efficient online shopping for unfamiliar brand names. A major difference in the experimental setting in the two studies is the task assigned to

the users. In Chau et al.'s study, users were asked to search for a particular brand name, while in our study, users were asked to browse the product listings and pick a brand based on their preferences. Therefore, users can benefit more from the dual coding of product images when browsing than when searching for a specific brand. This finding helps to clarify the applicability of dual coding theory in understanding users' online shopping performance. Specifically, presentation mode is moderated by the shopping task, i.e., whether the task is browsing for an item based on personal preference or searching for a specific item.

Consistent with the dual coding theory, a strong "picture superiority effect" was observed among users conducting online shopping. While both product images and brand names were provided in all the experimental conditions (in the text-only condition, the images were only provided on the detailed product information pages), users' recall of images was significantly better than their recall of brand names, confirming that images can be remembered more easily than text information. Furthermore, the advantages of providing images together with brand names on the product listing pages were reflected in reduced information search time, better recall of images, and more positive attitudes towards both the screen design and using the website.

An unexpected finding is that better recall of images does not coincide with better recall of brand names. A possible explanation is that although better recall of brand names is expected due to the dual coding of images, the effect is diluted as less attention will be paid to brand names when images are available. Besides being easier to encode, images are also more attractive than textual brand names. As human attention is a limited resource (Lachman et al., 1979; Van der Heijden, 1992), the processing of brand names will decrease when more attention is directed at the images. The two effects operate in opposite directions, and result in insignificant total effect on the recall of brand names.

6.2. The PCP and Information Format

The experiment results also demonstrate the efficacy in applying the proximity compatibility principle to e-commerce research. Traditionally, the PCP theory is applied to the design of engineering systems, such as adapter boards and engine meters (Barnett and Wickens, 1988; Wickens and Andre, 1990). Recent studies tend to use the PCP in a wider range of areas. For example, Atkins et al. (2002) successfully applied PCP in the design of feedback format (tabular versus graphic) of an inventory management task. Also, Smelcer and Carmel (1997) used the PCP in comparing the effectiveness of different presentations (tables versus maps) in solving managerial problems. In both studies, strong support for the PCP was found. However, our study is the first attempt in applying the PCP to e-commerce research. Note that there are fundamental differences between engineering or managerial tasks and e-commerce shopping tasks. In engineering or managerial tasks, users are often required to retrieve data values from the design, such as the temperature of the engine or the inventory level. While in e-commerce tasks, more semantic processing is needed when users need to read the brand names, compare the attributes of products, and examine the product images. For engineering or managerial tasks, there are often right or wrong answers where efficiency and accuracy are key indicators of success. On the other hand, in e-commerce, users are free to make their choices and there is normally no time constraint (unlike an aviation system, where misreading the altitude or not reading it in time may cause the plane to crash!). Therefore, users are under very different mental conditioning when they shop online as compared to when they are trying to solve a problem.

Despite these fundamental differences, our findings show that the PCP can successfully predict users' online shopping performance under different information formats, as reflected by shorter information search time and better recall of product information. Moreover, users' attitude towards using the website can be affected by the spatial arrangement of products on the

listing pages. The results suggest that the PCP is a versatile theory that can be applied to a variety of tasks and especially to the design of Web interfaces.

6.3. Implications

There is an increased interest among human-computer interaction (HCI) researchers in identifying the important website design features and providing website design guidelines. Ivory and her colleagues have conducted a series of studies (Ivory et al., 2000; Ivory et al., 2001; Ivory and Hearst, 2002) in which they examined the significance of 157 website design features on over 5,000 websites. They further classified the page-level and site-level design features into nine categories, i.e., text elements, link elements, graphic elements, text formatting, link formatting, page formatting, page performance, and site architecture. Their comprehensive list of website design metrics provides a framework based on which more detailed analysis on one or more design features can be performed. There are a number of ways to build on their research findings.

First, their website design metrics are empirically derived by examining design features that are significantly related to experts' ratings of the websites. To improve the theoretical validity of the design metrics, theories from cognitive psychology, HCI, and even engineering can be employed. Second, rigorous controlled experimental studies are needed to verify the effect of individual design features. Third, due to the large number of design metrics, it is infeasible to examine all the interaction effects among the design features, e.g., the interaction between text elements and page formatting, or the interaction between graphic elements and site architecture. A review of the existing HCI literature on website design shows that while some studies have started to examine multiple design features (e.g., Padovani and Lansdale, 2003), most studies still focus on a single design feature (e.g., Bayles, 2002; Fang, 2000; Potelle and Rouet, 2003; Yu and Roh, 2002; Zhang and Salvendy, 2001). We believe that going beyond a

single design feature and relating it to other design features is essential to arrive at a more thorough understanding of their effects on website users. For example, in our study, the presentation mode concerns both graphic elements and site architecture, and the information format involves both text formatting and page formatting.

The results of this research provide some useful guidelines to website designers. Two of the major decisions that website designers face are how to arrange the pre-determined information on the limited screen space, and the placement of information in the hierarchical structure of a website. Our findings indicate that these decisions can have a significant impact on users' online shopping performance and attitudes.

One implication of this research is to provide images, in addition to brand names, on the product listing pages of the website. Images can help users to remember products better by building strong connections between product images and brand names. They also make it easier for users to examine and compare products, and subsequently conduct more efficient shopping. Our results are particularly encouraging because providing images together with brand names leads to shorter information search time, but not at the expense of lower recall of alternative products. Users can recall more images and the same number of brand names when images are available on the product listing pages in addition to the detailed product information pages. The inclusion of images also makes the design of product listing pages more attractive to users and improves their attitude towards using the website. As a result, users with more positive attitudes are more likely to shop at a website utilizing the image-text presentation mode.

A second implication is to organize the products in a list information format on the product listing pages. This information format is suitable for users who are browsing for potential products to purchase. By arranging products closer together, users can examine and compare multiple brands of products more effortlessly, without the need to move their eyes,

heads, or internal attention as often as in the array information format. Consequently, users can spend more effort on processing the information, resulting in both shorter information search time and better recall of information presented on the screen. Furthermore, although spatial arrangement is a subtle design feature that may not be noticed by the users (in contrast, animation is a strong design feature that attracts attention), users do hold more positive attitude towards using the website when products are organized in the list than in the array information format.

6.4. Limitations and Future Research

A limitation of the study is the small number of items used to measure attitude towards using the website. In future research, this instrument may be strengthened with the inclusion of additional items. While this study has examined two popular presentation modes and two common types of information formats, there exist other types of presentation mode and information format used in commercial websites. It will be fruitful to examine them in future research. Future research can also examine the effects of presentation modes and information formats under different shopping conditions. Different mechanisms may affect the performance and attitudes of users who are familiar with the brands of products. For example, the effect of images may be stronger for familiar brand names. Meanwhile, a user who is very specific about what to purchase may be better supported by an array information format. In this condition, the user does not have to compare multiple brands of products and therefore the processing proximity is low.

7. Conclusion

This research reports on an empirical study of two design features of product listing pages on users' online shopping performance and attitudes. The findings from the experiment suggest that even when the information content is fixed (such as which products to advertise online and at

what prices), the design of product listing pages still has a significant impact on information search time, recall of brand names and product images, and attitudes towards the screen design and using the website. Specifically, providing product images together with the brand names on the product listing pages is superior to providing brand names alone. Similarly, arranging the products in a list information format rather than an array information format can provide more benefits to users.

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Sensation Generation Facial Tissues	HK\$ 9.90
Sani-Hanks Facial Tissues	HK\$ 9.25
Sorbert Facial Tissues	HK\$ 9.99
Earth Wise Facial Tissues	HK\$ 9.05
Sunpass Facial Tissues	HK\$ 9.50
Aspen Facial Tissues	HK\$ 9.10

Figure 1a: Screen Capture of Image-Text Presentation Mode and List Information Format

HK\$ 9.90	HK\$ 9.25	HK\$ 9.99
Sensation Generation Facial Tissues	Sani-Hanks Facial Tissues	Sorbert Facial Tissues
HK\$ 9.05	HK\$ 9.50	HK\$ 9.10
Earth Wise Facial Tissues	Sunpass Facial Tissues	Aspen Facial Tissues

Figure 1b: Screen Capture of Image-Text Presentation Mode and Array Information Format

Sensation Generation Facial Tissues	HK\$ 9.90
Sani-Hanks Facial Tissues	HK\$ 9.25
Sorbert Facial Tissues	HK\$ 9.99
Earth Wise Facial Tissues	HK\$ 9.05
Sunpass Facial Tissues	HK\$ 9.50
Aspen Facial Tissues	HK\$ 9.10

Figure 1c: Screen Capture of Text-Only Presentation Mode and List Information Format

HK\$ 9.90	HK\$ 9.25	HK\$ 9.99
Sensation Generation Facial Tissues	Sani-Hanks Facial Tissues	Sorbert Facial Tissues
HK\$ 9.05	HK\$ 9.50	HK\$ 9.10
Earth Wise Facial Tissues	Sunpass Facial Tissues	Aspen Facial Tissues

Figure 1d: Screen Capture of Text-Only Presentation Mode and Array Information Format

Sensation Generation Facial Tissues

Price :HK\$ 9.90

Size :70 CT

Unit Price :HK\$ 14.14/100CT

Additional description:

*Directions : Not recommended for cleaning eyeglasses.

*Description : Tissue has a moisturizing lotion with Aloe & Vitamin E. Three layers thick.

BUY THIS ONE

GO BACK TO LIST

Figure 1e: Screen Capture of Detailed Product Information Page

Table 1. Summary of Hypotheses

Dependent Variables	Independent Variables	
	Presentation Mode	Information Format
Information search time	H1a: Image-Text < Text-Only	H1b: List < Array
Recall of images	H2a: Image-Text > Text-Only	H2b: List > Array
Recall of brand names	H3a: Image-Text > Text-Only	H3b: List > Array
Attitude towards the screen design	H4a: Image-Text > Text-Only	H4b: List > Array
Attitude towards using the website	H5a: Image-Text > Text-Only	H5b: List > Array

Table 2. Subjects

Presentation Mode	Information Format	
	List	Array
Image-text	28	29
Text-only	25	25

Table 3. Factor Analysis of Multiple-Item Constructs

	Attitude towards the screen design	Attitude towards using the website
Attitude towards the screen design 1	0.908	-0.062
Attitude towards the screen design 2	0.743	0.022
Attitude towards the screen design 3	0.872	0.080
Attitude towards using the website 1	0.197	0.761
Attitude towards using the website 2	-0.089	0.976

Note: Figures are factor loadings.

Table 4. Hypotheses Testing Results for Presentation Mode

Dependent Variables	Mean (Std. Dev.)		Hypotheses Testing			Hypotheses Supported
	Text-only	Image-text	Mean difference	F statistic	Significance level	
<i>Information search time</i>	25.74 (5.08)	19.37 (3.81)	6.37	$F = 56.775$	$p = 0.000^{***}$	H1a: Yes
<i>Recall of images</i>	2.97 (1.61)	3.61 (1.38)	-0.64	$F = 5.125$	$p = 0.026^*$	H2a: Yes
<i>Recall of brand names</i>	2.11 (1.27)	2.21 (1.04)	-0.10	$F = 0.222$	$p = 0.639$	H3a: No
<i>Attitude towards the screen design</i>	5.29 (1.66)	6.34 (1.42)	-1.05	$F = 12.451$	$p = 0.001^{***}$	H4a: Yes
<i>Attitude towards using the website</i>	4.62 (1.92)	5.64 (1.69)	-1.02	$F = 8.976$	$p = 0.003^{**}$	H5a: Yes

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5. Hypotheses Testing Results for Information Format

Dependent Variables	Mean (Std. Dev.)		Hypotheses Testing			Hypotheses Supported
	List	Array	Mean Difference	F statistic	Significance level	
<i>Information search time</i>	21.37 (5.78)	23.31 (4.99)	-1.94	$F = 5.555$	$p = 0.020^*$	H1b: Yes
<i>Recall of images</i>	3.62 (1.38)	3.01 (1.60)	0.61	$F = 4.582$	$p = 0.035^*$	H2b: Yes
<i>Recall of brand names</i>	2.47 (1.11)	1.86 (1.12)	0.61	$F = 7.672$	$p = 0.007^{**}$	H3b: Yes
<i>Attitude towards the screen design</i>	5.95 (1.51)	5.75 (1.73)	0.20	$F = 0.617$	$p = 0.434$	H4b: No
<i>Attitude towards using the website</i>	5.57 (1.79)	4.77 (1.87)	0.80	$F = 5.749$	$p = 0.018^*$	H5b: Yes

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

APPENDIX A: Calculation of the Spatial Display Proximity

The display proximity is simulated as the distance from the center of one product to the center of the other product. Assuming there are six products on a 12cm by 18cm screen, there will be a total of 15 ($=C_2^6$) unique pairs of products in both the list and the array information formats. The average of these 15 distances is an indication of the display proximity. Note that changing the screen size will not affect the relative display proximity of these two information formats.

Array

A	B	C
D	E	F

List

A
B
C
D
E
F

Pairs	Distance (cm)
A - B	6
A - C	12
A - D	6
A - E	8.5
A - F	13.4
B - C	6
B - D	8.5
B - E	6
B - F	8.5
C - D	13.4
C - E	8.5
C - F	6
D - E	6
D - F	12
E - F	6
Total	126.8
Average	8.45

Pairs	Distance (cm)
A - B	2
A - C	4
A - D	6
A - E	8
A - F	10
B - C	2
B - D	4
B - E	6
B - F	8
C - D	2
C - E	4
C - F	6
D - E	2
D - F	4
E - F	2
Total	70.0
Average	4.67

APPENDIX B: Perception Measures***Attitude towards the screen design***

Please indicate the degree to which you would agree with the following statements by choosing a number from 1 to 10:

- 1) I think the screen design of the website is uncomfortable/comfortable.

Uncomfortable									Comfortable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9	10

- 2) I think the screen design of the website is unpleasant /pleasant.

Unpleasant									Pleasant
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9	10

- 3) I dislike/like the screen design of the website.

Dislike									Like
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9	10

Attitude towards using the website

Please indicate the degree to which you would agree with the following statements by choosing a number from 1 to 10:

- 1) I would dislike/like using a website built upon this model to perform similar shopping activities.

Dislike									Like
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9	10

- 2) Using a website built upon this model to perform similar shopping activities would be pleasant/unpleasant (R).

Pleasant									Unpleasant
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7	8	9	10

R: The item was reverse scaled.