Information Systems Research

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Does Animation Attract Online Users' Attention? The Effects of Flash on Information Search Performance and Perceptions

Weiyin Hong, James Y. L. Thong, Kar Yan Tam,

Information Systems Research
Vol. 15, No. 1, March 2004, pp. 60–86
ISSN 1047-7047 | EISSN 1526-5536 | 04 | 1501 | 0060

DOI 10.1287/isre.1040.0017

Does Animation Attract Online Users' Attention? The Effects of Flash on Information Search Performance and Perceptions

Weiyin Hong
Department of Management Information Systems, University of Nevada–Las Vegas, 4505 Maryland Parkway, Las Vegas, Nevada 89154, whong@unlv.nevada.edu

James Y. L. Thong, Kar Yan Tam
Department of Information and Systems Management, School of Business and Management, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong
{jthong@ust.hk, kytam@ust.hk}

The proliferation of information on the Internet poses a significant challenge on humans' limited attentional resources. To attract online users' attention, various kinds of animation are widely used on websites. Despite the ubiquitous use of animation, there is an inadequate understanding of its effect on attention. Focusing on flash animation, this study examines its effects on online users' performance and perceptions in both task-relevant and task-irrelevant information search contexts by drawing on the visual search literature and two theories from cognitive psychology. In the task-relevant context, flash is applied on the search target; while in the task-irrelevant context, flash is applied on a nontarget item. The results of this study confirm that flash does attract users' attention and facilitates quicker location of the flashed target item in tightly packed screen displays. However, there is no evidence that attracting attention increases recall of the flashed item, as is generally presumed in practice, and may even decrease the overall recall. One explanation is that when users have to use their limited attentional resources on suppressing the distraction of flash, they will have less mental resources to process information. Moreover, the results suggest that processing information about an item depends not only on the attention it attracts per se, but also on the attention that other items on the same screen attract. While flashing an item may not increase the recall of that item, it can reduce the recall of other items (especially the nontarget items) on the screen. Finally, flash has negative effects on users' focused attention and attitude towards using the website. These results have implications for website interface design, online product promotion, online advertising, and multimedia training systems, among others.

Key words: flash animation; attention; online information search; visual search; central capacity theory; associative network model; laboratory experiment; website interface design
History: Jane Webster, Associate Editor. This paper was received on January 23, 2002, and was with the authors 12 months for 3 revisions.

> What information consumes is rather obvious: It consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention.
>
> —Herbert Simon

1. Introduction

With the rapid development of multimedia and Internet technologies, information systems (IS) designers have a rich collection of tools available when designing both traditional and Web-based information systems. Among the various multimedia technologies (e.g., audio, video, and animation), animation has received much attention from both IS academics and practitioners. A review of the human-computer interaction (HCI) literature found that animation is often adopted in IS for three functions: (1) "look and feel," e.g., novelty and entertainment (e.g., Dholakia and Rego 1998, Thomas and Calder 2001), (2) information visualization to increase comprehension (e.g., Baecker 1988, Mackinlay et al. 1994), and (3) attracting users' attention to specific information on the screen (e.g., Chimera and

Shneiderman 1994, Nielsen 2000). While the first two functions of animation are generally supported by the literature, the third function is in need of a more thorough investigation as suggested by a number of researchers. In a study on user engagement in multimedia training systems, Chapman et al. (1999) concluded that it is unclear whether multimedia elements can help to maintain users' attention on a learning task or distract them from the task, and the authors called for more research in this area. When applying animation techniques together with group support systems to support user involvement in organizational change processes, Vreede (1997–1998) acknowledged that if improperly used, animation may overwhelm the users and turn them into interested viewers rather than critical thinkers. As Lim and Benbasat (2000, p. 464) pointed out, "...the new challenge is to derive a set of guidelines on how and when to use this rich array of tools (text, graphics, audio, video, and animation)...."

Research on simple forms of animation (e.g., blink coding), as part of system interface design, first appeared as early as the 1960s. It was found that a moving or flashing element is useful for attracting attention to a certain part of the screen because of its visual distinctiveness (Cropper and Evans 1968, Smith and Goodwin 1971). However, it was also recognized that such attention-attracting coding can be "distracting," "obtrusive," "disruptive," and "fatiguing" (McCormick 1970, Stewart 1976). On one hand, these findings remain insightful because of the slow physiological evolution of humans. On the other hand, the computing environment has been undergoing dramatic changes in the past couple of decades (e.g., the replacement of monocolor, small screen cathode ray tubes with multicolor liquid crystal displays). Hence, findings in these early studies may not adequately address the issues brought about by the new computing environment. With advances in graphical technologies in the 1980s, interface designers and IS researchers started to focus on the use of tables and graphics in supporting human decision making (see DeSanctis 1984, Jarvenpaa and Dickson 1988 for reviews). Other related interface variables, such as color (Benbasat and Dexter 1986) and spatial layout (Umanath et al. 1990) have also been examined. However, given the difficulties in applying animation in the traditional IS (Thomas and Calder 2001), none of these studies have examined animation as an interface design variable.

With the widespread adoption of Internet technologies such as Java and Virtual Reality Modeling Language, animation has become much easier to create and increasingly popular on the Web (Spool et al. 1999, Zhang 2000). One often encounters flashing objects, popups, and moving text when surfing the Internet. A major reason for using animation is to attract users' attention. Attention is a scarce resource on the Web (Davenport and Beck 2001, Glazer 1998), because of the vast amount of information available (Alba et al. 1997, Jarvenpaa and Todd 1996–1997) and the limited attention span of humans (Broadbent 1954, Lachman et al. 1979, Van der Heijden 1992). While there is enthusiasm for Web animation as being "cool," "engaging," and "entertaining" (Dolgenos 1996, McFarland 2000, Rewick 2001), it is balanced by the recognition that it can also be "annoying," "irritating," and even "evil" (McGalliard 1998; Nielsen 1996, 1997; Spool et al. 1999). Sharples (1999) suggested that animation may help keep users' attention and even boost sales at e-commerce websites when it is relevant to the users' tasks. Given the promising Web animation technology and the scarcity of human attention on the Internet, a more complete understanding of the effects of animation on attention will inform the design of websites.

In the marketing literature, researchers are interested in the use of animation for banner ads on websites to attract users' attention and increase the "click-through" rate. Li and Bukovac (1999) found that animated banner ads can be more quickly identified and better recalled as compared to still banner ads. Cho et al. (2001) concluded that a higher degree of forced exposure to animated banners ads will yield a higher click-through rate and more favorable attitudes among users. On the other hand, Tuten et al. (2000) noted that whether animation will provide an edge in attracting attention and generating click-through rates depends on the users' tasks. Users who are surfing for fun or for relaxation are more likely to be attracted by animated banner ads than users who are searching the Internet for specific information. Bruner and Kumar (2000) found that experienced users are less likely to be distracted by competing stimuli on the Web. Dahlen's (2001) study provides further evidence that the effectiveness of animated banner ads depends on both user experience and brand familiarity. In general, marketing researchers recognize that animation has the potential to attract users' attention but its effects seem to vary under different conditions. The mixed results point to the hypothesis that the effect of animation on attention, recall, user attitude, display characteristics, and tasks are interrelated and warrant more thorough analyses. Also, these studies only focused on the banner ads and did not investigate them in a broader context (e.g., effects on other items on the screen or perceptions of the websites using the animation), which is of interest to IS researchers.

Surprisingly, empirical research on animation in the IS literature is scarce. A notable exception is Zhang's (2000) study on the effects of animation on information search performance. The author found that irrelevant animation can reduce the performance of information seeking because it distracts users' attention from the core task. Zhang's (2000) study can be extended in a number of ways. First, the information-seeking tasks used in Zhang's (2000) study, i.e., searching for target strings of letters among an array of meaningless strings of letters, are significantly different from the typical Web information search tasks (e.g., searching for a product). Second, the study used irrelevant animation as stimuli, while in the real Web environment, animation can be applied to promotional items or to highlight important information (e.g., British Broadcasting Corporation (BBC) weather center), which are potentially relevant to the viewers. Finally, the relatively large number of tasks (20) assigned to each of the 24 subjects might have an effect on the subjects' concentration and affected their performance. We believe an empirical study of animation in a more realistic e-commerce environment, in a wider application context (i.e., both relevant and irrelevant to users' tasks), and with a more manageable number of tasks using a larger sample will contribute to a more comprehensive understanding of the effects of animation on online users.

Among the different types of animation, flash[1] is a simple but widely used form of animation on the Web (Rewick 2001). In addition, as flash bears the basic characteristic of animation (i.e., a constant change in the visual field), findings derived from flash can be extended to other types of animation that share this basic characteristic.[2] Hence, we will investigate flash animation in this study. The online information search environment is chosen for three reasons. First, information search is a major activity that online users perform (Park and Kim 2000, Smith et al. 1997). Second, information search is the main context in which prior visual search research has been conducted. Third, the results involving information search will build on Zhang's (2000) findings. Therefore, information search serves as a useful starting point for elucidating the effects of flash on websites.

To gain a more complete understanding of the consequences of Web animation, this study will examine the effects of flash in an online information search environment under both task-relevant and task-irrelevant conditions. When flash is applied on the target of search, it is considered as task relevant; when flash is applied on a nontarget item, it is considered as task irrelevant. Whether flash attracts users' attention is examined in terms of response time, which is defined as the time taken to locate the target item. Response time is generally used as an indicator of information search efficiency in traditional visual search research. Presumably, if flash attracts users' attention, it will shorten their response time when task relevant, and increase their response time when task irrelevant. If flash does attract attention, a subsequent question is whether attention leads to better recall. Recall is defined as a person's ability to retrieve information from memory that has been earlier acquired and retained (Large et al. 1994). It is of particular interest to online retailers and advertisers, as they want their websites to effectively convey product information to users. Davenport and Beck (2001, p. 37) noted that recall can be a good measure of attention as it indicates the quality of attention. To answer these questions, we make reference to the visual search literature (e.g., Yantis and Egeth 1999),

[1] In this study, "flash" does not refer to the commercial software "Macromedia Flash" but to a blink coding.

[2] Note that the opposite may not be true. For example, findings on a cute cartoon animation may not be applicable to a simple flash animation, as subjects may hold positive attitude toward the cartoon character.

the central capacity theory (Kahneman 1973), and the associative network model (Collins and Loftus 1975) in understanding the effects of flash on response time and recall. Besides the performance measures, users' perceptions of their Web experience are also central to the success of a website (Singh and Dalal 1999). Hence, this study also examines users' focused attention,[3] which is the centering of attention on a limited stimulus field such as on a computer screen (Csikszentmihalyi 1977), while completing the information search tasks and their attitudes toward using the website as measures of their Web experience. By including both objective and subjective performance measures, we aim to derive a more complete understanding of the effects of flash on online users' information search.

The next section presents the theoretical background of this research, including visual search research, central capacity theory, and the associative network model, and develops the hypotheses. The experimental design is then described in §3. Section 4 presents the results of data analysis. Section 5 discusses the findings, limitations, and directions for future research. Finally, §6 summarizes this paper and provides implications.

2. Theoretical Background and Hypotheses

HCI researchers have developed models such as GOMS (Card et al. 1983) and EPIC (Kieras et al. 1997) to simulate human information processing and predict human behavior when interacting with computers. However, these models do not account for the effects of special visual elements such as animation. Based on an extensive review of the literature on cognitive psychology, attention theories, and visual search studies, we decided to draw on the visual search research (e.g., Yantis and Egeth 1999) to examine how flash affects information search efficiency, the central capacity theory (Kahneman 1973) to understand allocation of attentional resources in the presence of flash, and the associative network model (Collins and Loftus 1975, Nelson et al. 1993, Quillian 1969) to understand the interaction between target and nontarget items on the screen.

2.1. Visual Search Research—Salience and Task Relevance

Human attention is considered to be limited, and hence is allocated selectively to objects in the visual field (Lachman et al. 1979, Van der Heijden 1992, Vecera and Farah 1994). Visual search research suggests that the ability to draw attention depends on both the salience of visual objects and whether they are relevant to the information search tasks. Salience refers to the phenomenon where one's attention is differentially directed to portions of the environment (Taylor and Thompson 1982). Salience can be conferred by local contrast in any of the basic visual features such as color, size, or motion. Support for the ability of salient objects to attract human attention and shorten information search time can be found in various visual search theories, including similarity-based theory (Duncan and Humphreys 1989), local feature contrast theory (Nothdurft 1993), and the guided search model (Wolfe et al. 1989). Meanwhile, there is also experimental evidence indicating that salient objects may fail to attract attention when they are irrelevant to the search task (Hillstrom and Yantis 1994, Jonides and Yantis 1988, Lamy and Tsal 1999, Todd and Kramer 1994).

Visual search researchers explain the above phenomenon by arguing that salient features only attract attention when they are relevant or *perceived* to be relevant to the search tasks (Bacon and Egeth 1994, Folk et al. 1992, Yantis and Egeth 1999), i.e., when applied to the target item, or *perceived* to be relevant to the target item. In other words, when subjects have reasons to believe that some salient features are totally irrelevant to their search tasks, they are capable of ignoring them in their information search to a certain degree.[4] Hence, the following discussion on the effects of flash on information search differentiates between task-relevant and task-irrelevant conditions. In the task-relevant condition, a salient feature (i.e., animation) is applied to the search target; and in

[3] Here, focused attention comes from the flow literature and is a self-reported measure of subjects' degree of concentration when performing a given task. It should be differentiated from the "focused attention" variable in the cognitive psychology literature, where it is a synonym for "selective attention" and refers to the ability to pick out some information from a mass of data.

[4] For example, it may be more difficult to ignore a moving salient feature than a color salient feature.

the task-irrelevant condition, it is applied to a nontarget item. We are interested in studying whether the use of animation on websites always attracts attention as generally believed, especially when it is unrelated to the search task. And if it does, how well can the animated item be recalled and how are unanimated items on the screen affected?

2.2. Does Flash Attract Attention? Response Time

If flash attracts attention, it should have an impact on users' information search efficiency. Response time, which is defined as the time taken to locate the target item, is often adopted in traditional visual search research as a reflection of information search efficiency. It is also a common measure for IS performance (e.g., Benbasat and Dexter 1985, Jarvenpaa 1989).

According to visual search research, a salient feature that is applied on the target of search can be detected efficiently in visual search (Nothdurft 1993, Neisser 1967). Flash is a highly salient feature as it continuously changes the appearance of the visual field by shifting between "on" and "off." When flash is applied on the target item that users are searching for on a website, it can direct their attention to the target item immediately without the need to scan the items on the screen. Therefore, compared to a static website, response time is likely to be shorter when the target item is flashed on a website.

Hypothesis 1a. *Response time will be shorter when the target item is flashed compared to when it is not flashed.*

When a nontarget item is flashed, the situation is more complicated. Visual search research suggests that whether a salient feature affects information search depends on both its task relevance and salience (Theeuwes 1990, Yantis and Egeth 1999). There is evidence that people are able to ignore some irrelevant salient features, such as unique color or brightness, but not others, such as onset (i.e., one element appearing abruptly in a previously blank location, which has some similarity to flash) when they are searching for a target item (Jonides and Yantis 1988, Theeuwes 1990). Girelli and Luck's (1997) study provides a plausible explanation for the phenomenon by showing that the attentional mechanisms used in color or orientation are entirely different from those used in motion detection and that human attention is much more sensitive to motion than color or orientation. In the Web environment, when users visit a website that they are not familiar with, they will have difficulty judging in advance whether a flashed item is relevant or not to their search task. And even if they have reasons to believe that all animation is irrelevant (e.g., banner ads), to totally ignore it can still be difficult. In fact, Spool et al. (1999) noted that users often scroll the animation off the screen or cover it with their hands to focus their reading on the rest of the information on the screen. If users cannot ignore the irrelevant flashing item, visual search research suggests that their information search efficiency is likely to be compromised, resulting in longer response time in searching for the target item (Jonides 1981, Jonides and Yantis 1988).

Hypothesis 1b. *Response time will be longer when a nontarget item is flashed compared to when it is not flashed.*

Visual search research has also found that the effectiveness of salient features in facilitating target detection increases with local density (Bacon and Egeth 1991, Bravo and Nakayama 1992). Local density measures how "tightly packed" the items are over the information space (Tullis 1983).[5] The closer the items are on the display, the higher the local density. Note that given the same amount of information displayed over an area, local density could vary (e.g., one with all items packed into one corner of the display, while the other with items evenly dispersed across the entire display). There are several explanations for why local density could affect the effectiveness of salient features in expediting information search. First, the deployment of focused attention to a salient feature is more efficient when local density of the feature contrast is steeper (Bravo and Nakayama 1992). Second, it could be that as the average distance between nontarget items decreases in high local density displays, increased grouping among the nontarget items will result, which, in turn, makes them easier to reject as

[5] "Local density" needs to be differentiated from "overall density," which is defined as the total amount of information displayed on a single frame (Tullis 1983), or "the percentage of active screen area" (Danchak 1976). As noted by Tullis (1983), it is possible to have two displays with the same overall density, but different local density. It should also be distinguished from "grouping," which is often related to the relevance of items on a display in the HCI literature (e.g., similar items should be grouped together) (Stewart 1976).

a group (Bacon and Egeth 1991). Smith and Goodwin (1971) found that saving in search time resulting from blink coding (which has some similarity to flash in this study) is greater for displays of higher local density. Therefore, the effect of flash on response time is expected to be moderated by the local density of information display on the website. When the target item is flashed, the saving in response time is expected to be larger in high local density than in low local density environments. Similarly, when a nontarget item is flashed, the interference effect on information search will be stronger in high local density environments, resulting in an increase in response time being larger in the high local density than in low local density environments.

Hypothesis 1c. *Response time reduces to a greater extent in high than in low local density environments when the target item is flashed compared to when it is not flashed.*

Hypothesis 1d. *Response time increases to a greater extent in high than in low local density environments when a nontarget item is flashed compared to when it is not flashed.*

2.3. Does Attention Lead to Better Recall?

If flash does attract attention, an important question is whether it leads to better recall. Attracting users' attention and keeping them online is not the end itself, but a means to an end for many e-commerce applications. The ultimate objective is to imprint a message (e.g., product information) in the mind of viewers. For example, whether a product promotion or an ad banner is effective or not is measured by the extent viewers can form an impression of the advertised product and recall it at a later stage. Recall has traditionally been used in IS (e.g., decision support system, multimedia training system) research as a dependent variable reflecting the effectiveness of information transmission by different system interface designs (DeSanctis 1984, Large et al. 1994, Umanath et al. 1990). Davenport and Beck (2001, p. 37) noted that recall is also a good measure of attention, because it indicates the *quality* of attention in addition to the *quantitative* measure of time. This study is interested not only in how overall recall performance is affected in both task-relevant and task-irrelevant conditions, but also how flash affects the recall of individual items on the screen. The central capacity theory and the associative network model from cognitive psychology are utilized to understand the effects of flash on recall performance.

2.3.1. Central Capacity Theory—Resource Limitation. It is widely acknowledged that a human's capacity to process information is limited (Broadbent 1954, Lachman et al. 1979, Van der Heijden 1992). Despite this limited capacity, humans seem to be able to divide their attention among different tasks (Eysenck and Keane 1995). For example, one can ride a bicycle, examine the road conditions, and talk to a friend simultaneously. Kahneman (1973) proposed a limited capacity model of attention, which has a central processor that allocates attention. In Kahneman's (1973) model, parallel processing in attention is possible, where the limited attentional resource is allocated among different tasks. The amount of attention that each task receives depends on the difficulty of the task and the degree of practice that an individual has in it. The concept of a central attention capacity is also assumed by other attention theories, such as McLeod's (1977) parallel processing model and Norman and Bobrow's (1975) central capacity interference theory.[6]

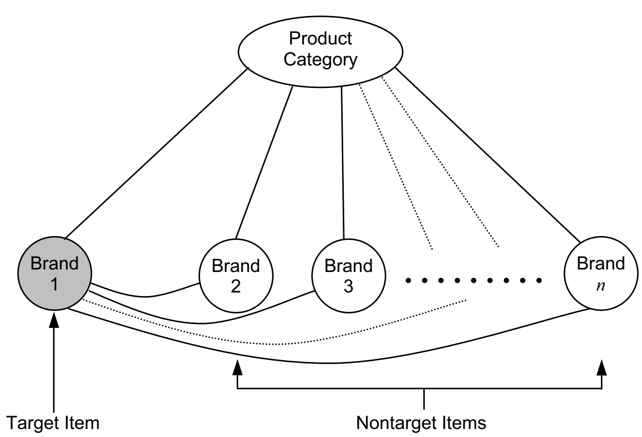
According to the central capacity theory, if users need to spend attentional resources to suppress the interference of flash, they will be left with fewer resources for the central task of information processing. Hence, the central capacity theory suggests that when an item is flashed on the website, information processing of the other nonflashed items will decrease as some of the attentional resources are spent on suppressing the interference of flash. The amount of information processing received by an item has a direct impact on the user's ability to recall it at a later stage.

[6] There are also models that assume there are multiple resources available for different tasks (e.g., Navon and Gopher 1979, Wickens 1984). To read a novel and listen to music simultaneously is easy because they use different attention resources (one is aural, the other is visual), but to read a novel and watch television simultaneously is relatively difficult because they consume the same type of visual resource. As only visual effects are studied here, it is likely that only a single resource of visual attention is involved, which makes it similar to the situation studied in the central capacity model.

2.3.2. Associative Network Model—Reinforcement Effect. A webpage consists of many information items. The relative salience of an item affects not only the amount of information processing allocated to it, but it also affects the processing of other items on the same page. Before discussing the recall of individual items on a website, it is important to understand the relationship between the target item and nontarget items in human mental representation. According to the associative network model of mental representation (Collins and Loftus 1975, Nelson et al. 1993, Quillian 1969), information items are organized in a network structure. The network is composed of nodes and associative links among the nodes. Nodes are fixed points in the memory structure that can represent a unit of information. For example, product categories and brand names are presented as nodes in Figure 1. Furthermore, some nodes are connected to other nodes via associative links, which provide meaning regarding the relationship between each pair of nodes.

The associative network model provides an explanation for the retrieval of information from memory. The process of information retrieval is called "activation" (Anderson 1983, Collins and Loftus 1975, de Groot 1989). Activation happens when a node is stimulated from a state of rest, either directly through an external stimulation (e.g., online user reading an advertisement), or indirectly (through the process of spreading activation from linked nodes). A basic assumption of the associative network model is that activation of a single node will spread out along all the links connected to it to other nodes with a decreasing gradient of strength. Therefore, nodes with more associative links are more likely to be retrieved because there are more "paths" through which they can be activated. The associative network model has been applied successfully to a wide range of processes, such as the construction of personal impressions in social psychology (Wyer and Srull 1989) and the relationship among products, brands, and endorsers in the marketing domain (e.g., Samu et al. 1999, Till and Shimp 1998).

Figure 1 **Associative Network Model of Target and Nontarget Items**



The associative network model can help to explain online users' memory of the target item and the nontarget items on a website. Assuming that users are searching for a particular brand of product at an unfamiliar website, memory of the brands on that particular website can be simulated as shown in Figure 1. First, all the brands belong to a product category, so whenever a brand is encountered, the link between the corresponding brand node and the product category node will be activated. A side effect of an activation is a more strengthened link between the category and the brand. Hence, the brands that have been repeatedly activated are more likely to be recalled than the brands that have not been examined. Moreover, during the process of searching for the target item, users need to compare each brand with the target brand to verify whether it is the target. This will lead to the establishment of additional links from some of the nontarget brands (those that have been examined) to the target brand. Therefore, according to the associative network model, the target item is more likely to be recalled than nontarget items, as there are more associative links connected to the target item. Activating any of the nontarget items will help to strengthen its link to the target item, which makes the target item easier to recall.

2.3.3. Recall of the Target Item. According to visual search research, attention can be involuntarily captured by moving objects or new objects segregated from the background when they are the targets of search (James 1950, p. 417; Hillstrom and Yantis 1994). Therefore, when the target item is flashed on a website, it is likely to draw attention from users because of its salience. Prior empirical findings suggest that more attention leads to better recall (see Taylor and Fiske 1978 for a discussion). Therefore, there is a higher chance to recall the target item when it is flashed than when it is not flashed. However, the associative network model (Collins and Loftus 1975) suggests that recall of the target item is affected not only by the attention it gets per se, but also by the processing of other nontarget items. When the target item is flashed, reinforcement is less likely to build up because there is no repeated comparison between target and nontarget items. The search stops immediately after the user locates the target item. In summary, the two theories propose opposite effects and it is not clear which effect will be stronger. Therefore, we propose a difference in the recall of the target item when it is flashed compared to when it is not flashed.

Hypothesis 2a. *Recall of the target item will be different when it is flashed compared to when it is not flashed.*

Next, we consider the recall of the target item when a nontarget item is flashed on the website. Following the central capacity theory (Kahneman 1973), as attention will be attracted to the flashed nontarget item, effort must be made to suppress the distracting effect of flash once it is found not to be the target. This reduces the attentional resources available for processing other items, resulting in reduced recall of the target item. On the other hand, more nontarget items (especially the flashed item) are likely to be processed before the target item is identified. According to the associative network model (Collins and Loftus 1975), repeated comparisons with the target item are made during the search. This will result in more reinforced links spreading out from the target item. Therefore, the reinforcement effect is likely to be stronger when a nontarget item is flashed than when it is not flashed. Again, these two effects work in opposite directions, and it is not obvious which effect is stronger. Hence, we hypothesize that there will be a difference in the recall of the target item when a nontarget item is flashed compared to when it is not flashed.

Hypothesis 2b. *Recall of the target item will be different when a nontarget item is flashed compared to when it is not flashed.*

2.3.4. Recall of the Flashed Nontarget Item. According to visual search research (Joseph and Optican 1996, Pashler 1988), when a nontarget item is flashed and users do not know in advance whether it is task related or not, their attention is likely to be directed to the flashed item immediately. As shifting attention to other items will incur a cost, it is more cost beneficial to examine whether the current item under focal attention is the search target before moving on. Therefore, the flashed item will be semantically processed and compared to the target item before it is rejected. Compared to the no-flash condition, where all items on the screen have an equal chance of being processed, flash provides the nontarget item an advantage in attentional resource allocation. Also, comparing the flashed nontarget item with the target item will strengthen the associative link between the flashed item and the target item, and increase the chances of both of them being recalled (Collins and Loftus 1975). Therefore, recall of the flashed nontarget item should be higher when it is flashed compared to when it is not flashed.

Hypothesis 2c. *Recall of the nontarget item will be higher when it is flashed compared to when it is not flashed.*

2.3.5. Recall of the Nontarget Items That Are Not Flashed. According to the central capacity theory (Kahneman 1973), when more attentional resources are spent on suppressing the interference of flash, less attention will be available to process the nonflashed items, resulting in decreased recall of nontarget items that are not flashed in both the task-relevant and task-irrelevant conditions. Specifically, when the target item is flashed, visual search research (Smith and Goodwin 1971, Yantis and Jonides 1984) suggests that users' attention will be directed to it and they will end the information search once they establish that it is the target item. Therefore, we hypothesize that recall of the nontarget items will be lower when the target item is flashed compared to when it is not flashed. When a nontarget item is flashed, users need to proceed with their information search once they verify that the flashed item is not the target item. The information search among the remaining items becomes more difficult as some of the attentional resources will be spent on suppressing the distracting effect of flash. Therefore, we expect that recall of the nontarget items that are not flashed will be lower when a nontarget item is flashed compared to when it is not flashed.

Hypothesis 2d. *Recall of the nontarget items will be lower when the target item is flashed compared to when it is not flashed.*

Hypothesis 2e. *Recall of the nontarget items that are not flashed will be lower when a nontarget item is flashed compared to when it is not flashed.*

2.3.6. Overall Recall Performance. The central capacity theory (Kahneman 1973) indicates that overall recall performance will be lower with the presence of flash on the screen. This will be true for both the task-relevant and task-irrelevant conditions. In terms of reinforcement effect through the associative network (Collins and Loftus 1975), fewer items are likely to be visited in the task-relevant condition before the target item is identified. Hence, fewer links will be activated and overall recall performance will be impaired. Combining these two effects, we hypothesize that the overall recall performance will be lower when the target item is flashed compared to when it is not flashed.

Hypothesis 2f. *Overall recall will be lower when the target item is flashed compared to when it is not flashed.*

When a nontarget item is flashed, the overall recall performance is also expected to be lower because the presence of flash will reduce attention capacity (Kahneman 1973). Meanwhile, greater reinforcement effect is expected because on average, more nontarget items are likely to be processed before the target item is identified, resulting in the activation of more links in the associative network (Collins and Loftus 1975). In summary, the theories propose opposite effects. Hence, we hypothesize that there is a difference in the overall recall performance when a nontarget item is flashed compared to when it is not flashed.

Hypothesis 2g. *Overall recall will be different when a nontarget item is flashed compared to when it is not flashed.*

2.4. Does Flash Affect Online Users' Perceptions? Focused Attention and Attitude

2.4.1. Focused Attention. One potential negative effect of flash is that it disturbs concentration (Nielsen 1995, Spool et al. 1999, Stewart 1976). Focused attention refers to a "centering of attention on a limited stimulus field" (Csikszentmihalyi 1977, p. 40). Flash will make it difficult for users to focus on their information search task, because it constitutes a constant change in the visual field. As human attention is highly sensitive to movement in the environment, the continuous blinking will prevent concentration. This will be true whether the flashed item is the search target or not. While some people (e.g., Sharples 1999) believe that animation related to users' tasks will help users concentrate on their tasks and have a more engaging experience, this is more likely to be the case when the animation is less obtrusive and more informative, such as an animated virtual character (e.g., a virtual teacher guides users through online learning activities) (André and Rist 2002). For the simple form of flash, we expect the disturbing effect to be stronger, and therefore propose that focused attention will be lower when the target item is flashed compared to when it is not flashed. When a nontarget item is flashed, users are more likely to feel disturbed, because flash makes it difficult for them to process other information, including the target item. Therefore, focused attention will be lowered by flash in both task-relevant and task-irrelevant conditions.

Hypothesis 3a. *Focused attention will be lower when the target item is flashed compared to when it is not flashed.*

Hypothesis 3b. *Focused attention will be lower when a nontarget item is flashed compared to when it is not flashed.*

2.4.2. Attitude Towards Using the Website. Users' attitudes toward using the website is another dependent variable of interest. Attitude is defined as an individual's positive or negative feelings about performing a behavior (Ajzen and Fishbein 1980). Because flash can direct users' attention to the target item and reduce their information search time, their attitudes are likely to be more favorable toward using a website where the target item is flashed. On the other hand, flash can cause visual fatigue, annoyance, and irritation (Smith and Goodwin 1971, Spool et al. 1999, Stewart 1976), which will negatively affect attitudes toward using the website. Therefore, we predict a difference in users' attitudes toward using the website when the target item is flashed. In the task-irrelevant condition, flashing a nontarget item will make it difficult to search for the target item on the website. Coupled with the negative visual effects of flash, users' attitudes toward using the website are likely to be less favorable when a nontarget item is flashed compared to when it is not flashed.

Table 1 Summary of Hypotheses

Dependent Variables	Task-Relevant Condition	Task-Irrelevant Condition
Response time	Hypothesis 1a: Flash $<$ no flash Hypothesis 1c: Interaction: high local density $>$ low local density	Hypothesis 1b: Flash $>$ no flash Hypothesis 1d: Interaction: high local density $>$ low local density
Recall of brand name	Hypothesis 2a: Target item (flashed): flash $\neq$ no flash	Hypothesis 2b: Target item (not flashed): flash $\neq$ no flash Hypothesis 2c: Nontarget item (flashed): flash $>$ no flash
	Hypothesis 2d: Nontarget items (not flashed): flash $<$ no flash Hypothesis 2f: Overall: flash $<$ no flash	Hypothesis 2e: Nontarget items (not flashed): flash $<$ no flash Hypothesis 2g: Overall: flash $\neq$ no flash
Focused attention	Hypothesis 3a: Flash $<$ no flash	Hypothesis 3b: Flash $<$ no flash
Attitude towards using the website	Hypothesis 4a: Flash $\neq$ no flash	Hypothesis 4b: Flash $<$ no flash

Hypothesis 4a. *Attitudes toward using the website will be different when the target item is flashed compared to when it is not flashed.*

Hypothesis 4b. *Attitudes toward using the website will be less favorable when a nontarget item is flashed compared to when it is not flashed.*

Table 1 summarizes the hypotheses for both the task-relevant and task-irrelevant conditions.

3. Methodology

3.1. Design, Subjects, and Experimental System

A 2×3 between-subject, full-factorial design was employed. The no-flash condition served as the control condition. It was compared with both the task-relevant (flashed target item) and task-irrelevant (flashed nontarget item) conditions. All three treatments of flash were tested in both high and low local density environments, resulting in a total of six experimental conditions.

One hundred and eighty-six subjects were recruited from a public university in Hong Kong. They were paid US$7 for their participation in the experiment. The subjects were randomly assigned to one of the six experimental conditions. All the experimental sessions were conducted in a laboratory with 60 identical Pentium III PCs connected to the Internet.

An online grocery shopping system, written in ASP and Java, was developed specifically for the experiment. It was installed on a Win2000 server in the same local area network as the personal computers (PCs) in the laboratory to ensure a consistent high network speed for all subjects. The subjects accessed the shopping system using the same Internet browser, i.e., Internet Explorer 5.5.

3.2. Independent Variables

The information search task was framed in the context of online shopping. Each subject took part in six shopping trips using the experimental website, and was required to search for one brand in each of the six product categories. There were six brands in each product category. A product listing page that contained basic information about the six brands, including brand names, product images, and price, was created for each product category. In the no-flash condition, all brands in the six product categories were kept static. Flash was manipulated by applying a blink coding to one of the six brands in each product category. In the task-relevant condition, the target brand in each product category was flashed. In the task-irrelevant condition, one of the five nontarget brands was picked randomly and flashed, while the target brand remained static.

The local density of information display on the website was manipulated by the spatial arrangement of the items on the screen. Two popular forms of information presentation on the Web, the list (see Figure 2a) and the matrix information formats (see Figure 2b), were used in the experiment. In the list information format, only one item is displayed on each row, while in the matrix information format, there is more than one item on each row. In this study, both list and matrix information formats, representing high and low local density environment, respectively, were developed for the website (see Figures 3a and 3b). Although these two information formats have the same screen size and the same number of items on the screen (i.e., the same overall density), they vary in their local density. The list information format represents a high local density environment,

Figure 2a Example of List Information Format

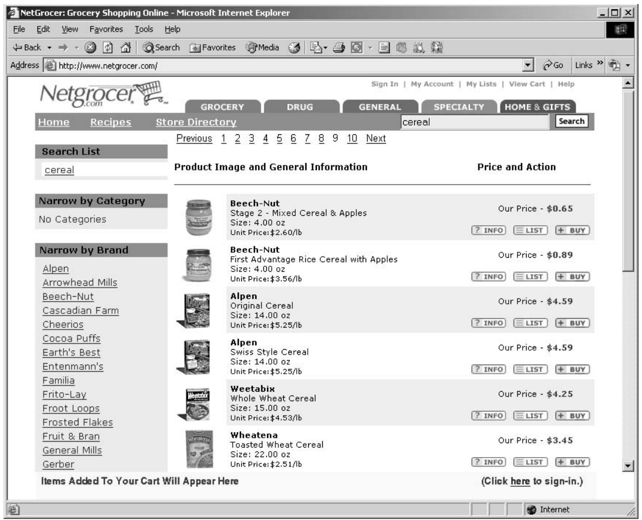
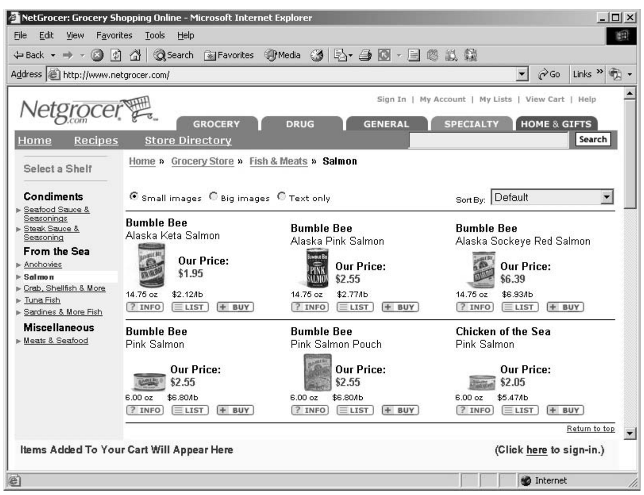


Figure 2b Example of Matrix Information Format



as the average distance between two items on the screen is 4.67 cm, which is 45% less than the average distance of 8.45 cm in the matrix information format, which is a low local density environment (see Appendix A). Product information, font size, image size, and color scheme were held constant across both information formats.

3.3. Dependent Variables

Response time was measured in seconds by averaging the search time taken to locate the target brands across the 6 product categories based on the computer log file. Recall was assessed as the recall of brand names

Figure 3a List Information Format on the Experimental Website

Figure 3b Matrix Information Format on the Experimental Website

that had appeared on the experimental website. The subjects were presented with 12 brand names (6 valid brands and 6 invalid brands) for each product category, and were asked to identify the brand names that they had previously seen during their shopping trips. Therefore, each subject could make a maximum of 36 correct identifications, including 6 target brand names and 30 nontarget brand names. The recall performance scores were computed as the average number of correct identifications across the 6 product categories. And for each product category, the overall recall performance was calculated as the number of correct identifications out of the 6 brand names. Recall of the flashed target brand name was calculated as the average number of correct identifications of the flashed target brand name across the 6 product categories. Recall of the flashed nontarget brand name was calculated in a similar way. Finally, recall of the nontarget brand names that were not flashed was calculated as the average number of correct identifications of the nontarget brand names that were not flashed across the 6 product categories, divided by the total number of nontarget brand names that were not flashed (i.e., 5 brands in the task-relevant condition and 4 brands in the task-irrelevant condition).[7] In summary, the unit for recall is per brand for the recall of individual items and per 6 brands for the overall recall. For example, a recall score of 0.847 for the target brand means that, on average, subjects can recall 0.847 brand out of the 1 target brand in each of the six shopping trips, or that the target item can be successfully recalled 84.7% of the time. Similarly, an overall recall score of 1.698 means that, on average, subjects can recall 1.698 brands out of the 6 brands, or that they can recall 28.3% of the brands ($1.698/6 = 28.3\%$).

The perception measures were administered in a postsession questionnaire (see Appendix B). The four items used to measure focused attention were taken from the flow literature as applied to the online environment (Novak et al. 2000). Following the guidelines of Ajzen and Fishbein (1980), attitude towards using the website was measured by two items with paired anchors of like and dislike and pleasant and unpleasant, respectively. A 10-point Likert scale was used for both measures. The variables demonstrated adequate reliability, with Cronbach alphas of 0.87 for focused attention and 0.76 for attitude towards using the website. Construct validity was assessed by factor analysis. All items loaded significantly higher on the variable they were designed to measure than on the other variable, with all factor loadings greater than 0.70 and no cross loadings higher than 0.10, indicating high construct validity.[8]

3.4. Control Variables

The online shopping experiment could be affected by the characteristics of the subjects (e.g., prior online shopping experience) and product attributes (e.g., price). Multiple methods were used to control for the effects of possible confounding variables and increase the internal validity of this study. Individual differences, including personality, cognitive style, PC experience, and Web experience, were controlled for by randomly assigning the subjects to the experimental conditions. Aside from the monetary incentive for participation, the subjects were also given an opportunity to win one of the products they purchased during the experiment based on their successful completion of the shopping tasks and their recall performance.[9]

Previous literature suggests that product class knowledge and brand familiarity could influence online users' information search and shopping behavior (Brucks 1985, Dodds et al. 1991). A pretest involving 29 subjects was conducted to select 6 product categories with similar levels of familiarity for our subject pool and 6 fake or unfamiliar brand names within each category. These product categories and brand names were then used in the experiment. Finally, as the order of presentation on the screen might affect users' information search and decision-making processes (Marshall et al. 1987, Umanath et al. 1990), the order of the 6 brands in each shopping trip was balanced with a Latin square design (Kirk 1995). Similarly, the order of the six shopping trips was balanced using the same Latin square design.

3.5. Experimental Procedure

All the experimental sessions were administered by the same experimenter following a standard protocol. At the start of each experimental session, the subjects were told that all the instructions were provided online and that they should read the instructions carefully and complete the experiment independently. The subjects first entered their demographic information online. Next, a cover story was provided to the subjects. They were told that an international company was intending to market its products online and had developed a website. The subjects then conducted a trial shopping trip for a product category, other than the six in the main experiment, to familiarize themselves with the website and the shopping

[7] The division is used to standardize the measure to allow equitable comparison between the two conditions.

[8] A confirmatory factor analysis performed using LISREL (see Appendix C) also supported the construct validity of the variables (Byrne 1998).

[9] Subjects were not informed of this opportunity until they came to the recall task. Hence, their shopping behavior would not be affected by it.

process. Following this, a description of the shopping task was given. The subjects were told that people usually shop online with specific target items in mind, seeking time saving and convenience. Therefore, supposing that they need to buy specific brands of products online, they would want to complete the purchases quickly and accurately. The subjects then conducted a total of six shopping trips. During each trip, they were asked to search for a particular brand of product on the website. A log file was generated to store the subjects' clickstream data. After the shopping trips, the subjects completed a postsession questionnaire regarding their perception of the website and their shopping experience. This was followed by the task to recall brand names.

4. Data Analysis

The log file of the subjects' clickstream data was analyzed to see whether they understood the experiment instructions correctly. Those subjects who made at least two incorrect purchases (i.e., selecting the wrong brands) during the six shopping trips were deemed to have failed to complete the tasks and were dropped from subsequent analyses. This resulted in 172 valid data sets (see Table 2).

4.1. Control and Manipulation Checks

Among the 172 subjects, 61% were females and 39% were males. On average, the subjects had used PCs for 5.83 years and the Internet for 3.38 years. Only 16.9% of the subjects had previous online shopping experience. Control checks on gender and subjects' experience with PCs, the Internet, and online shopping were performed. A multivariate analysis of variance (MANOVA) test confirmed that the random assignment of subjects to the experimental conditions was successful. There were no significant differences in gender ($F = 0.638$, $p = 0.671$), experience with PCs ($F = 0.401$, $p = 0.848$), the Internet ($F = 0.993$, $p = 0.424$), and online shopping ($F = 1.558$, $p = 0.175$) among the six experimental groups.

Table 2 **Subjects**

Information Format	Flash		
	No Flash	Task Relevant (Flash a Target Item)	Task Irrelevant (Flash a Nontarget Item)
List	27	31	26
Matrix	31	27	30

As there were more female subjects than male subjects, the dependent variables for the two groups were compared using t-tests. There were no significant differences between females and males in their response time ($t = -0.690$, $p = 0.491$), recall of brand names ($t = 1.155$, $p = 0.250$), focused attention ($t = 0.426$, $p = 0.670$), and attitude towards using the website ($t = 1.547$, $p = 0.124$). Statistical tests were also performed to see if there were any systematic biases in the dependent variables because of subjects' experience with PCs, the Internet, and online shopping. There were no significant correlations between these control variables and the dependent variables. Hence, none of the control variables had a significant effect on the dependent variables under investigation.

4.2. Hypotheses Testing: Task-Relevant Condition

Table 3 presents the hypotheses testing results for the task-relevant condition. Analysis of variances (ANOVAs) were used in hypotheses testing. The main effects of flash and local density on response time were not significant. However, there was a significant interaction effect between flash and local density, supporting Hypothesis 1c. A detailed examination of the data pattern (see Figure 4a) showed that when the target item was flashed, response time decreased in the high local density environment (list format), but increased in the low local density environment (matrix format). Therefore, Hypothesis 1a was partially supported, as it holds in the high local density but not the low local density environment. Hypothesis 1c was supported as the decrease in response time was larger in the high local density than in the low local density environment (the increase in response time in the low local density environment could be viewed as negative).

Recall of the target brand name decreased significantly when it was flashed (from 84.7% to 65.2%), supporting Hypothesis 2a. Consistent with Hypothesis 2d, recall of nontarget brands also decreased when the target item was flashed (from 17.0% to 10.2%). Finally, the overall recall of brand names was found to be lower when the target item was flashed (1.164 out of 6 brands or 19.4%) than when it was not flashed (1.698 out of 6 brands or 28.3%), supporting Hypothesis 2f.

Table 3 Hypotheses Testing Results for the Task-Relevant Condition

Dependent Variables	Mean	Standard Deviation	F	p
Response time				
Flash				
no flash	4.74	1.81	0.006	0.940
flash target	4.78	1.86		
Local density				
high local density	4.83	2.09	0.192	0.663
low local density	4.62	1.54		
Flash × local density				
no flash + high local density	5.23	2.15	5.211	0.024*
no flash + low local density	4.31	1.34		
flash target + high local density	4.49	2.00		
flash target + low local density	5.11	1.66		
Recall (target item)				
Flash				
no flash	0.847 (84.7%)	0.20	20.964	0.000***
flash target	0.652 (65.2%)[a1]	0.25		
Recall (nontarget items)				
Flash				
no flash	0.170 (17.0%)	0.20	4.836	0.030*
flash target	0.102 (10.2%)[a2]	0.11		
Recall (overall)				
Flash				
no flash	1.698 (28.3%)	1.00	11.541	0.001**
flash target	1.164 (19.4%)[a3]	0.66		
Focused attention				
Flash				
no flash	7.64	1.39	4.854	0.030*
flash target	7.05	1.44		
Attitude towards using the website				
Flash				
no flash	6.61	1.61	3.107	0.081
flash target	6.08	1.74		

Note. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.
[a1] 0.652 out of 1 target brand is equivalent to a recall rate of 65.2%.
[a2] 0.102 out of every 1 nontarget brand is equivalent to a recall rate of 10.2%.
[a3] 1.164 out of a total 6 brands is equivalent to a recall rate of 19.4%.

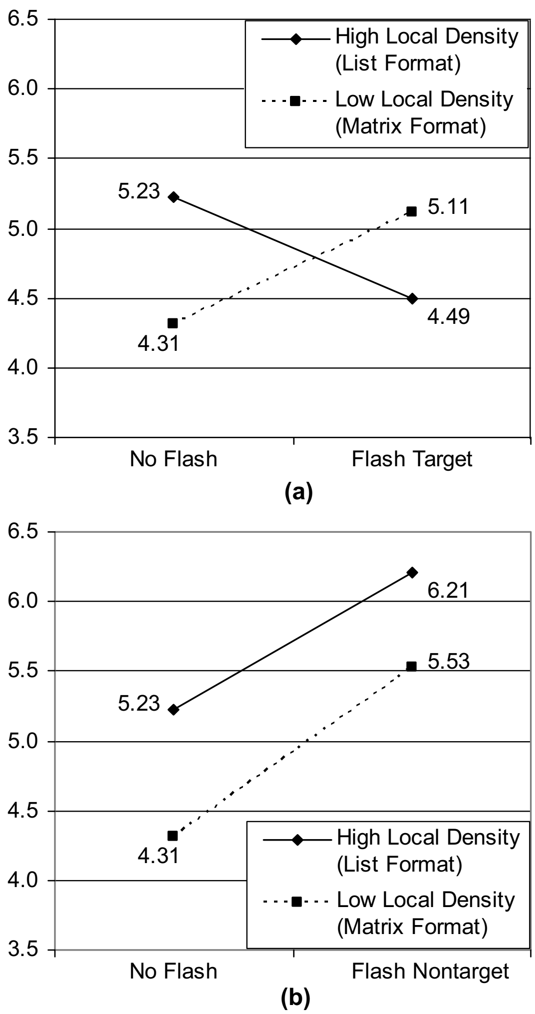
An ANOVA test showed that subjects' focused attention was affected negatively when the target item was flashed on the website, supporting Hypothesis 3a. Attitude towards using the website was not affected by the flashed target brand. Hence, Hypothesis 4a was rejected. A summary of the hypotheses testing results for the task-relevant condition is presented in Table 4.

4.3. Hypotheses Testing: Task-Irrelevant Condition

Table 5 presents the hypotheses testing results for the task-irrelevant condition. The main effect of flash on response time was supported. Response time was significantly longer when a nontarget item was flashed than when it was not flashed, supporting Hypothesis 1b. However, Hypothesis 1d was rejected as the interaction between flash and local density was not significant. There was no significant difference in the increase in response time between the high local density (i.e., list format: $6.21 - 5.23 = 0.98$ seconds) and the low local density (i.e., matrix format: $5.53 - 4.31 = 1.22$ seconds) environment (see Figure 4b).

Recall of the target item remained unchanged when a nontarget item was flashed, rejecting Hypothesis 2b. Contrary to Hypothesis 2c, recall of the nontarget item did not improve when it was flashed compared to when it was not flashed. On the other hand,

Figure 4 (a) Mean Levels of Response Time in the Task-Relevant Condition; (b) Mean Levels of Response Time in the Task-Irrelevant Condition



recall of the other nontarget items (not flashed) decreased significantly (from 17.0% to 9.6%), supporting Hypothesis 2e. Finally, the overall recall of brand names decreased significantly when a nontarget item was flashed (from 28.3% to 22.4%), supporting Hypothesis 2g.

Similar to the results in the task-relevant condition, subjects found their focused attention affected negatively when a nontarget item was flashed, thus supporting Hypothesis 3b. Attitudes toward using the website were less positive when a nontarget brand was flashed, supporting Hypothesis 4b. A summary of the hypotheses testing results for the task-irrelevant condition is presented in Table 6.

We also performed statistical power analyses (Cohen 1988) on the insignificant findings. Prior to conducting the experiment, we have estimated that for a sample size of 172 and assuming a medium effect size, the powers of the statistical tests would be higher than the recommended value of 0.80 (with 0.90 for local density, 0.83 for flash, and 0.83 for the interaction between flash and local density). The posthoc power analyses using the actual effect sizes obtained from the experiment showed the following results—Hypothesis 1a: response time (effect size = 0.01, power < 0.15); Hypothesis 1d: response time interaction between flash and local density (effect size = 0.03, power < 0.15); Hypothesis 2b: recall of target item (effect size = 0.05, power = 0.13); Hypothesis 2c: recall of nontarget item (effect size = 0.10, power = 0.28); and Hypothesis 4a: attitude towards using the website (effect size = 0.17, power = 0.43). The low powers of the insignificant tests were because

Table 4 Summary of Hypotheses Testing Results for the Task-Relevant Condition

Dependent Variables	Hypotheses	Results
Response time	Hypothesis 1a: Flash < no flash	Partially supported (for high local density)
	Hypothesis 1c: Interaction: high local density > low local density	Supported
Recall of brand name	Hypothesis 2a: Target item (flashed): flash ≠ no flash	Supported
	Hypothesis 2d: Nontarget items (not flashed): flash < no flash	Supported
	Hypothesis 2f: Overall: flash < no flash	Supported
Focused attention	Hypothesis 3a: Flash < no flash	Supported
Attitude towards using the website	Hypothesis 4a: Flash ≠ no flash	Rejected

Table 5 Hypotheses Testing Results for the Task-Irrelevant Condition

Dependent Variables	Mean	Standard Deviation	F	p
Response time				
Flash				
no flash	4.74	1.81	6.845	0.010*
flash nontarget	5.85	2.63		
Local density				
high local density	5.71	2.65	3.599	0.060
low local density	4.91	1.92		
Flash × Local density				
no flash + high local density	5.23	2.15	0.083	0.774
no flash + low local density	4.31	1.34		
flash nontarget + high local density	6.21	3.04		
flash nontarget + low local density	5.53	2.23		
Recall (target item)				
Flash				
no flash	0.847 (84.7%)	0.20	0.241	0.625
flash nontarget	0.830 (83.0%)[a1]	0.18		
Recall (flashed nontarget item)				
Flash				
no flash	0.170 (17.0%)	0.20	1.069	0.303
flash nontarget	0.128 (12.8%)[a2]	0.22		
Recall (other nontarget items)				
Flash				
no flash	0.170 (17.0%)	0.20	5.227	0.024*
flash nontarget	0.096 (9.6%)[a3]	0.13		
Recall (overall)				
Flash				
no flash	1.698 (28.3%)	1.00	4.612	0.034*
flash nontarget	1.345 (22.4%)[a4]	0.73		
Focused attention				
Flash				
no flash	7.64	1.39	4.956	0.028*
flash nontarget	6.97	1.85		
Attitude towards using the website				
Flash				
no flash	6.61	1.61	6.598	0.012*
flash nontarget	5.77	1.90		

Note. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.
[a1] 0.830 out of 1 target brand is equivalent to a recall rate of 83.0%.
[a2] 0.128 out of 1 flashed nontarget brand is equivalent to a recall rate of 12.8%.
[a3] 0.096 out of every 1 nontarget brand that is not flashed is equivalent to a recall rate of 9.6%.
[a4] 1.345 out of a total 6 brands is equivalent to a recall rate of 22.4%.

of the much lower than expected effect sizes. With these small effect sizes, the sample size required to achieve a power of 0.80 for these tests ranged from 320 (for Hypothesis 4a) to 700 (for Hypothesis 2c) to more than 2,000 (for Hypothesis 1a, Hypothesis 1d, Hypothesis 2b). While a much larger sample is needed to confirm the findings, given the actual small effect sizes, there is no current evidence that the null hypotheses do not hold.

5. Discussion

Generally, the results suggest that flash is a salient factor that attracts users' attention. It can help reduce response time when applied to the search target in a high local density environment, but will interfere with the search when applied to a nontarget item on the screen. However, attention does not guarantee better recall, as both the overall recall performance and other brand-level recall performances dropped in

Table 6 Summary of Hypotheses Testing Results for the Task-Irrelevant Condition

Dependent Variables	Hypotheses	Results
Response time	Hypothesis 1b: Flash > no flash	Supported
	Hypothesis 1d: Interaction: high local density > low local density	Rejected
Recall of brand name	Hypothesis 2b: Target item (not flashed): flash ≠ no flash	Rejected
	Hypothesis 2c: Nontarget item (flashed): flash > no flash	Rejected
	Hypothesis 2e: Nontarget items (not flashed): flash < no flash	Supported
	Hypothesis 2g: Overall: flash ≠ no flash	Supported
Focused attention	Hypothesis 3b: Flash < no flash	Supported
Attitude towards using the website	Hypothesis 4b: Flash < no flash	Supported

the presence of flash. Moreover, flash has a significant negative effect on focused attention. Finally, it can even lower users' attitudes toward using the website under certain conditions.

5.1. Does Flash Attract Attention?

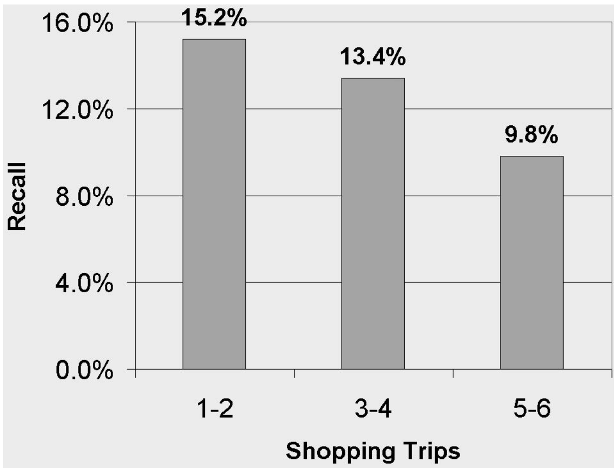
The findings that flash can significantly reduce response time in a high local density environment when applied to the search target and that it can significantly increase response time when applied to a nontarget item, suggest that flash is a salient feature that does attract attention. The attention-attraction effect of flash applied to the target item is moderated by the local density of the visual field. There is greater saving in response time when the local density of the display is high (the list information format) than when it is low (the matrix information format). A possible explanation is that in the low local density environment, where distances among the items are relatively large, the feature contrast in the local area is not as high as it is in the high local density environment. This will reduce the efficiency of directing attention to the salient feature. It appears that the flashed target item is more salient when closely surrounded by other items than if items are scattered further away from it. This is consistent with Nielsen's (1995, 2000) arguments that flash is only helpful when trying to identify a specific item among a large number of items on the screen. Another interesting finding is that the moderator effect of local density disappears when the flash is task irrelevant. One plausible explanation is that online users are able to proceed to search the remaining items without suffering from interference exerted by the flashing nontarget item. If they were not able to do so, there would be a stronger interference effect in the list than in the matrix information format, as the distances between items are smaller in the list format. This result is supportive of prior visual search research that viewers can control, to a certain degree, which salient features to attend to and which not to attend to under different conditions. Online users seem to be able to suppress the interference and proceed with their search with a certain level of efficiency.

5.2. Does Attention Lead to Better Recall?

First, overall recall performance was reduced whenever there is a flashed item on the screen. This finding provides support for the central capacity theory that online users' attentional resources are limited and multiple tasks will compete for the available attention. When attentional resources are spent on suppressing the interference effect of flash, there will be less resource available for information processing of the brand names. The effect of limited attentional resource is most evident in the task-irrelevant condition, where the negative effect of reduced resources is stronger than the positive effect of increased reinforcement in the associative network model, resulting in lower overall recall performance.

More direct evidence of users' active suppression of the distracting effects of flash can be found in the recall of the flashed nontarget item. If there is no active suppression, flash will draw extra attention to the nontarget item, and therefore lead to increased recall as compared to when it is not flashed. However, the findings show that recall of a nontarget item is not increased when it is flashed. Online users seem to be able to actively suppress the attention-attraction effect of flash as they learn that it is irrelevant to their

Figure 5 **Recall of the Flashed Nontarget Item**



information search. To test this argument, we compared the recall performance for flashed nontarget items across the six shopping trips (see Figure 5). The results showed that recall of flashed nontarget items decreased with the shopping experience, indicating that online users became better at suppressing the distracting effect of flash with practice. This may explain why users are able to ignore banner advertisements and competing product promotions when they are more familiar with a website.

A second major finding from the recall data is that the reinforcement effect was consistent with the associative network model of memory. The reinforcement effect refers to the fact that processing nontarget items will bolster processing the target item, because users need to compare them to determine whether they are the target or not. In the task-relevant condition, the extra attention that the target item draws could not compensate for the loss of reinforcement effect. This led to lower recall performance of the target item. Furthermore, in the task-irrelevant condition, the fact that recall of the target item was not reduced by flashing of a nontarget item indicates a strong reinforcement effect. Although less attention was allocated to the target item when a nontarget item was flashed, recall of the target item remained nearly constant because it had been indirectly reinforced when users processed the nontarget items. This result is intriguing because it suggests that the attention an item receives per se does not fully determine the degree of information processing devoted to it (recall is often assumed to be an outcome of information processing). The attention that other items receive can also affect the processing of the target item.

Further evidence that attention and processing of an item are affected by attention and processing of other items is indicated by recall of nontarget items that were not flashed. The recall of nonflashed items (excluding the target item) decreased when a flashed item was present. Clearly, as more attention is allocated to the flashed item, there is less attention available for nonflashed items. Therefore, while flash may not increase recall of the flashed item, it has adverse effects on the recall of nontarget items that are not flashed.

5.3. How Does Flash Affect Online Users' Perceptions?

In general, the findings indicate that flash will not be favored by online users, even if it helps with their information search on the website. Focused attention will always be disturbed by the presence of flash. This is consistent with findings from previous research on the use of animation (e.g., Nielsen 1996, Spool et al. 1999). Even if flash is applied to the target item, users still find it distracting, probably because flash makes it difficult to read the information itself (Smith and Goodwin 1972). Therefore, flash should be applied with care because of its negative effect on focused attention regardless of its task relevance.

In addition, online users' attitudes toward using the website will be less positive when an irrelevant item or an item that is not what they are looking for is flashed on the screen. Attitude towards using the website will not improve even when flash is applied to the target item. The benefit of flash in quickly identifying the target is probably counterbalanced by the visual discomfort and disturbance induced by flash (Smith and Goodwin 1971, Spool et al. 1999, Stewart 1976). Furthermore, when a nontarget item is flashed, the negative impact of flash on attitude becomes even more obvious. As attitude is believed to be an antecedent of behavior, online users who hold unfavorable attitudes toward a website are less likely to use it in the future. This finding suggests that Web designers need to be more conservative with the use of flash on their websites.

5.4. Limitations and Future Research

The limitations of this study include the use of student subjects and the relative simplicity of the experimental website and the experimental task. First, the use of student subjects is often criticized for lack of generalizability. For the phenomenon investigated in this study, this limitation is not a major issue. Researchers have acknowledged that the human visual perception, attention, and memory mechanisms were developed over many years, with conformity between individuals much greater than any variation due to individual differences (Besuijen and Spenkelink 1998). Therefore, the results should hold for different subject groups. Nevertheless, replicating this study with subjects that have different demographics will strengthen the findings.

Second, the design of the experimental website was simplified. The aim was to increase internal validity by controlling for the exogenous interface variables that might interact with the independent variables in this study. For example, if more brands were included on each page, then scrolling would become necessary, in which case, the flashed item may be scrolled off the screen. To attract users' attention, websites tend to keep their animations on the screen by putting them in a fixed frame at the top of the screen or floating them randomly on the screen. These situations are similar to those examined in this study. Therefore, although the design of the experimental website was relatively simple, it simulates a situation typical of online information search while maintaining internal validity.

Third, although the experimental task has been designed to simulate a realistic shopping condition on the Web, it may still appear contrived. As discussed above, such controls are necessary to ensure the internal validity of the experiment, as precise laboratory results are achieved mainly by controlled manipulation and eliminating possible "contaminating" conditions (Kerlinger 1992, p. 367). If increased external validity of the results is required, then a field study can be designed, but at the expense of lowered internal validity and precision of the results.

This study opens various avenues for future research. First, in this study, the effects of animation were examined in an information search context. Browsing is another major online activity that online users engage in. As browsing is very different from searching (e.g., users do not have specific target items in mind), it would be interesting to replicate this study in a browsing context. Second, it would be useful to investigate the effects of other forms of animation. Although the different types of animation share some common characteristics, such as motion, they may vary in other aspects, such as information richness (e.g., an animated picture has richer information content than blinking text) or level of annoyance (e.g., animation that will automatically stop after a certain duration of time is less annoying than animation that will not stop). Third, other interface characteristics, such as color of the background, can be examined together with animation. Local density (in this study) and brightness (in Zhang's 2000 study) have been found to interact with animation under certain conditions. A more complete understanding of the effect of animation can be obtained by examining it together with other interface characteristics. Finally, other types of attention-attracting interface design features, such as sound or video, can be studied in a wider range of IS applications, such as educational and training systems.

6. Conclusions

This study contributes to our understanding of the effects of flash, a common form of animation, on online users' information search performance and perceptions in both task-relevant and task-irrelevant conditions. There are six main findings. First, flash can increase the efficiency of information search only when it is applied to the search target and when the local density of information on the screen is high. In all other situations, it will decrease the efficiency of information search. Second, flash reduces the attentional resources available for information processing, resulting in lower overall recall performance, as users need to expend mental resources to suppress the distraction of flash. Third, the processing of an item depends not only on the attention it receives per se, but also on other items that appear on the same screen. Specifically, if an item is the search target, it will benefit from the processing of other items on the screen. However if the item is not the search target, it will suffer from the increased attention devoted to the other items. Fourth, although flashing an item may not increase recall of the item itself, it does reduce the recall of other items on the screen. Fifth, flash disturbs users' attempts to focus attention on information search, whether the flashed item is relevant or not. Finally, users have less favorable attitudes toward using a website when the flashed item is irrelevant to their information search task.

6.1. Theoretical Implications

This study has applied findings from visual search research and two theories from cognitive psychology to understand the effects of flash. The results confirm the appropriateness of referencing the visual search literature and applying the theories from cognitive psychology to the e-commerce domain.

While the visual search literature has been applied successfully in this study, it should be noted that the experimental conditions in typical visual search research are quite different from the current setting. First, as noted by Zhang (2000), the exposure time of stimuli in traditional visual search research is much shorter (milliseconds) than that on the Web (seconds or minutes).[10] Second, the stimuli in traditional visual search research involve only simple physical attributes (e.g., search for a red square among a group of green squares), while information presented on websites is rich and can be very complex (e.g., text and image). Third, in traditional visual search research, special equipment is used to display stimuli and capture responses, while in the online setting, users access information through Web browsers and their responses are captured by "clicks." Despite all these differences, the conclusion that flash is a salient feature in attracting attention is consistent with previous work, providing a validity check of the experimental setup. Furthermore, the current findings on recall performance, focused attention, and attitude towards using the website extend previous results to richer environments and improve their generalizability.

[10] One's visual attention may change during the relatively longer exposure time of the stimuli in the Web environment. However, this may not be a major issue as human evolution changes individual characteristics much more slowly than environmental changes (Zhang 2000).

The central capacity theory and the associative network model of memory from cognitive psychology provide a framework to understand the allocation of attention to the different items on a screen, and the relationship among the items. Although these theories originated in contexts very different from that of the Web, the human memory and attention mechanisms are likely to be similar across different contexts. Consequently, they also provide implications to a wider range of IS research. For example, Chapman et al. (1999) called for research into the relationship between the relevance of multimedia elements in a training system and users' attention to the task. Our findings suggest that a prominent multimedia element will attract users' attention to the task whether it is relevant or not. Therefore, a multimedia training system is more likely to attract attention compared to a text-only training system. Meanwhile, it is important that the multimedia element is closely related to users' tasks, otherwise it will distract their attention from the central tasks. This is particularly important because training tasks typically require learners' mental efforts and concentration in completing them. Having animation that is irrelevant to the training tasks will distract learners' attention and may even result in undesirable learning outcomes.

The findings of this study extend the results of previous HCI studies on simple forms of animation (such as blink coding) and increases our understanding of the role of animation as an attention-attracting interface design variable of IS. Limited by technological capability, animation has not been a design feature in traditional IS. However, with the rapid development of Internet technologies, animation is now added to the toolbox of IS designers. This research constitutes one of the first few attempts in studying animation as an interface design feature of modern IS.

While also focusing on Web animation, this study differs from the marketing literature on banner ads in important ways. First, in banner ads research, it is typically assumed that the animation under investigation is irrelevant to the tasks of online users. Our research supplements their findings by including both task-relevant and task-irrelevant conditions in the analyses. Second, the dependent variables used in the marketing literature are different from those of interest to IS researchers. While dependent variables such as brand awareness and consumer loyalty are of interests to marketing researchers, IS researchers focus more on information-related dependent variables, such as information search efficiency (as reflected by response time) and information transmission effectiveness (as reflected by recall of information). Finally, the marketing literature on banner ads often focuses on the banner ads themselves, and fails to analyze them in a wider context. However, from the website designer's point of view, it is important to examine the effects of animation on other displayed items, on the overall design evaluation, and on users' attitudes toward using the website. The current study complements marketing research on banner ads by examining animation in a wider context.

Finally, this study fills the gap between the lack of rigorous empirical research on Web animation in the IS literature and the wide adoption of animation on the Internet. Creating animation has become substantially easier with advances in animation software, such as Macromedia Flash, Fireworks, and Director Shockwave Studio. However, there are few rigorous empirical research studies on Web animation in the IS literature (see Zhang 2000 for an exception). This study extends Zhang's (2000) study by including both task-relevant and task-irrelevant conditions, simulating a more realistic e-commerce environment, and including more subjects in the experiment.

6.2. Practical Implications

"One of the most critical attention issues in electronic commerce is simply attracting it" (Davenport and Beck 2001, p. 115). The authors reported that users' attention is becoming so important that some online merchants are creating a new job position, *cognitive designers*, to examine the relationship between attention, behavior, and interface design. The findings of this study can help website designers by addressing general beliefs of using animation, and providing a more accurate and comprehensive understanding of its effects on online users' information search performance and perceptions.

Our findings indicate that strong attention-attracting interface features, such as flash, can help online users identify the search target quickly in tightly packed displays, such as in a list information format. However to do so, website designers need to successfully predict the target item that users are searching for. Some possibilities to ensure successful prediction are by examining the key words that online users entered or analyzing their purchase history. If the wrong item is flashed, it will decrease the efficiency of information search and disrupt focused attention, leading to less positive attitude towards the website.

On the other hand, online users can still block the information from being processed to a certain degree (which is supported by our finding that recall of an item is not higher when it is flashed compared to when it is not flashed), and this ability seems to improve with experience. In fact, as online users develop the ability to suppress the processing of items that they perceive to be irrelevant to their tasks, there is a chance that they may miss important information that the website intends to convey through eye-catching features, e.g., a typhoon alert on a flashing banner. For portals and company intranets that are developed for information dissemination, the use of flash animation should be restrained to avoid this problem.

The business models of many portals are premised on the belief that ad banners convey messages to viewers by drawing their attention. Banners are priced according to their size and location on the webpage with extra premium on animation effects. While a lot is at stake in animated banner ads, there is little work done so far to rigorously study their effects on attention drawing and their ability to implant a message in the viewers' memory. It is probably true that websites will continue to use animated banners for revenue generation; nevertheless, we believe a more complete and accurate understanding of the consequences of doing so is essential. Only by knowing the pros and cons of animation can one develop a Web advertising strategy that meets the needs of advertisers. Our results demonstrate how attention allocated to an item can affect attention paid to other items on the same screen. The effect can work in opposite directions. On one hand, when disproportionate attention is attracted by an item, recall of the remaining items is likely to suffer because of limited attentional resources. Currently, it is common to find companies placing competing ad banners on the same webpage (e.g., main page) of a portal. Knowing the effects of flash on recall from the current study, they may be reluctant to place their ads on a webpage that has flashing item(s). On the other hand, as items on the same webpage may have interrelationships (e.g., a webpage of a particular music CD album contains information on other albums of the same genre or other works by the same artist), processing of one item may activate the processing of other items. According to the associative network model, there could be situations where flashing an item may reinforce both the target and the flashed items, leading to better recall, at the expense of others. Portals may consider charging a premium price for animated banners in these situations if they can convince advertisers that recall of their brands will improve. In any case, as their knowledge of the behavior of online users increases, advertisers will no longer be satisfied with the simple click-through and eyeball measurements, and will demand more effective measurements for the return on investment of banner ads. This will have important implications for Web banner ad pricing.

Finally, most website designers are probably aware that irrelevant animation can often be annoying and online users dislike it. However, it is unclear whether the negative feelings will disappear if the animation turns out to be relevant to online users' tasks. Advances in personalization technologies have made it possible to provide customized Web interfaces for individual users and to infer their preferences from transactions and clickstream data mining. For example, animation can be applied to an item on promotion that is believed to be of interest to the online user, or when there is urgent information to be conveyed to the online user (e.g., a weather report showing that a tornado is approaching the vicinity where the online user resides). Unfortunately, our findings showed that even when animation is highly task relevant, users still feel their focused attention being distracted and will not develop more positive attitudes toward the website. Our suggestion for website designers would be that unless they are certain that online users will be interested in the flashed item, they may want to consider using less obtrusive design features, such as bigger sizes or brighter colors, to increase the salience of an item.

6.3. Epilogue

Increasingly, innovative and eye-catching multimedia technologies (including animation) are being deployed in a wide spectrum of IS applications to compete for people's limited attention. However, application of these technologies needs to be handled with care to reduce the potentially negative side effects, such as distracting users from their main task of using the IS, reducing the attention that other items attract, or generating negative feelings toward the system among users. System designers need to carefully balance the advantages and disadvantages of applying animation. A systematic examination of the pros and cons of different types of animation or other attention-attracting design features can help IS designers to make more prudent choices. Further research involving theories from cognitive psychology, especially those related to human attention allocation and information processing, will be useful in developing guidelines on the usage of these technologies in securing attention.

On a final note, this study illustrates how theories and research findings from HCI can inform IS research. While HCI and IS have developed independently, they have similar aspirations; both are interested in the productive application of IS to human organizations and their management. Their common objective is the development of IS that are usable and have positive impact on users and their organizations (Zhang and Dillon 2003). Corporate IS are increasingly Web based, allowing employees and even customers to access data and run applications via their Web browsers. The Web has become an important channel for an organization to not only interact with its employees, but to interact directly with its clients. As users interact with an IS[11] through its Web interface, the interface design has a major effect on their performance. One of the main streams of HCI research is the development of user-centered systems, and especially the interface design. It becomes important to understand the conditions and the process through which HCI technologies exert influence on the cognition and behavior of Web users. An interface with the right mix of technologies that fits the user's task can serve as a technology

[11] We include Web-based IS (e.g., websites) in the definition of IS.

leverage point to enhance performance. In this study, we have examined the effects of flash animation on information search performance and perceptions using various HCI theories; we have also drawn implications for website interface design, online product promotion, online advertising, and multimedia training systems, among others. Hence, there is much potential in applying theories and research findings from HCI to IS research.

Acknowledgments

The authors thank the Editor, Associate Editor, and three anonymous reviewers for their helpful comments and suggestions on earlier versions of this paper. They would also like to express their appreciation for comments from participants of research seminars at The Hong Kong University of Science and Technology. This project was partially funded by RGC Grant HKUST6194 and received financial support from the Research Center for Electronic Commerce at The Hong Kong University of Science and Technology.

Appendix A. Calculation of Average Distance Between Objects on the Screen

The distance between two objects is computed as the distance from the center of one object to the center of the other object. Assuming there are 6 objects on the screen, there will be a total of 15 ($=C_2^6$) unique pairs of objects in both the list and the matrix information formats. The average of these 15 distances is an indication of the density of the information format. A screen of 12 cm by 18 cm is assumed in the calculation. Note that changing the screen size will not affect the relative density of these two information formats.

Matrix

A	B	C
D	E	F

Pairs	Distance (cm)
A–B	6.0
A–C	12.0
A–D	6.0
A–E	8.5
A–F	13.4
B–C	6.0
B–D	8.5
B–E	6.0
B–F	8.5
C–D	13.4
C–E	8.5
C–F	6.0
D–E	6.0
D–F	12.0
E–F	6.0
Total	**126.8**
Average	**8.45**

List

A
B
C
D
E
F

Pairs	Distance (cm)
A–B	2.0
A–C	4.0
A–D	6.0
A–E	8.0
A–F	10.0
B–C	2.0
B–D	4.0
B–E	6.0
B–F	8.0
C–D	2.0
C–E	4.0
C–F	6.0
D–E	2.0
D–F	4.0
E–F	2.0
Total	**70.0**
Average	**4.67**

Appendix B. Perception Measures

Focused attention:

In terms of your shopping experience on the website, please indicate the degree to which you would agree with the following statements by choosing a number from 1 to 10:

(FA1) My attention was focused/my attention was not focused (*R*).

My attention was focused	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7	○ 8	○ 9	○ 10	My attention was not focused

(FA2) I was absorbed intensely/not absorbed intensely (*R*).

Absorbed intensely	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7	○ 8	○ 9	○ 10	Not absorbed intensely

(FA3) I was deeply engrossed/not deeply engrossed (*R*).

Deeply engrossed	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7	○ 8	○ 9	○ 10	Not deeply engrossed

(FA4) I concentrated fully/I did not concentrate fully (*R*).

I concentrated fully	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7	○ 8	○ 9	○ 10	I did not concentrate fully

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:

(ATT1) I would dislike/like using a website built on this model to perform similar shopping activities.

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

(ATT2) Using a website built on this model to perform similar shopping activities would be pleasant/unpleasant (*R*).

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

Note. R = The items were reverse scaled.

Appendix C. Confirmatory Factor Analysis of Perception Measures

Fit Indices for Measurement Model

Fit Indices	Recommended Value	Measurement Model
χ^2	N/A	12.59
df	N/A	8
χ^2/df	≤ 3	1.57
Goodness of fit	≥ 0.90	0.98
Adjusted goodness of fit	≥ 0.80	0.94
Normalized fit index	≥ 0.90	0.97
Nonnormalized fit index	≥ 0.90	0.98
Comparative fit index	≥ 0.90	0.99
Root mean square residual	≤ 0.10	0.086
Root mean square error of approximation	≤ 0.08	0.054

Factor Loadings and Significance

	Factor Loadings	t	p
Focused attention			
FA1	0.60	N/A	N/A
FA2	0.80	13.64	<0.01
FA3	0.93	8.56	<0.01
FA4	0.85	15.01	<0.01
Attitude towards using the website			
ATT1	0.76	N/A	N/A
ATT2	0.82	4.51	<0.01

References

Ajzen, I., M. Fishbein. 1980. *Understanding Attitudes and Predicting Social Behavior*. Prentice-Hall, Englewood Cliffs, NJ.

Alba, J., J. Lynch, B. Weitz, C. Janiszewski, R. Lutz, A. Sawyer, S. Wood. 1997. Interactive home shopping: Consumer, retailers, and manufacturer incentives to participate in electronic marketplaces. *J. Marketing* **61** 38–53.

Anderson, J. R. 1983. A spreading activation theory of memory. *J. Verbal Learn. Verbal Behavior* **22**(3) 261–295.

André, E., T. Rist. 2002. From adaptive hypertext to personalized Web companions. *Comm. ACM* **45**(5) 43–46.

Bacon, W. F., H. E. Egeth. 1991. Local processes in preattentive feature detection. *J. Experiment. Psych. Human Perception Performance* **17**(1) 77–90.

Bacon, W. F., H. E. Egeth. 1994. Overriding stimulus-driven attention capture. *Perception Psychophysics* **55**(5) 485–496.

Baecker, R. 1988. Enhancing program readability and comprehensibility with tools for program visualization. *Proc. 10th Internat. Conf. Software Engrg.*, Singapore, IEEE Computer Society Press, 356–366.

Benbasat, I., A. S. Dexter. 1985. An experimental evaluation of graphical and color-enhanced information presentation. *Management Sci.* **31**(11) 1348–1364.

Benbasat, I., A. S. Dexter. 1986. An investigation of the effectiveness of color and graphical information presentation under varying time constraints. *MIS Quart.* **10**(1) 59–83.

Besuijen, K., G. P. J. Spenkelink. 1998. Standardizing visual display quality. *Displays* **19**(2) 67–76.

Bravo, M. J., K. Nakayama. 1992. The role of attention in different visual-search tasks. *Perception Psychophysics* **51**(5) 465–472.

Broadbent, D. E. 1954. The role of auditory localization and attention in memory span. *J. Experiment. Psych.* **47**(3) 191–196.

Brucks, M. 1985. The effects of product class knowledge on information search behavior. *J. Consumer Res.* **12** 1–16.

Bruner, G. C., II, A. Kumar. 2000. Web commercials and advertising hierarchy-of-effects. *J. Advertising Res.* **40**(1–2) 35–42.

Byrne, B. M. 1998. *Structural Equational Modeling with LISREL, PRELIS, and SIMPLIS: Basic Concepts, Applications, and Programming*. Lawrence Erlbaum, Mahwah, NJ.

Card, S. K., T. P. Moran, A. Newell. 1983. *The Psychology of Human-Computer Interaction*. Lawrence Erlbaum, Hillsdale, NJ.

Chapman, P., S. Selvarajah, J. Webster. 1999. Engagement in multimedia training systems. *Proc. 23rd Hawaii Internat. Conf. System Sci.*, Maui, HI, IEEE Computer Society Press.

Chimera, R., B. Shneiderman. 1994. An exploratory evaluation of three interfaces for browsing large hierarchical tables of contents. *ACM Trans. Inform. Systems* **12**(4) 383–406.

Cho, C., J. Lee, M. Tharp. 2001. Different forced-exposure levels to banner advertisements. *J. Advertising Res.* **41**(4) 45–56.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed. Lawrence Erlbaum, Hillsdale, NJ.

Collins, A. M., E. F. Loftus. 1975. A spreading activation theory of semantic processing. *Psych. Rev.* **82**(6) 407–428.

Cropper, A. G., S. J. W. Evans. 1968. Ergonomics and computers. *Comput. Bull.* **12**(3) 94–98.

Csikszentmihalyi, M. 1977. *Beyond Boredom and Anxiety: Experiencing Flow in Work and Play*. Jossey-Bass, San Francisco, CA.

Dahlen, M. 2001. Banner advertisements through a new lens. *J. Advertising Res.* **41**(4) 23–30.

Danchak, M. M. 1976. CRT displays for power plants. *Instrumentation Tech.* **23**(10) 29–36.

Davenport, T. H., J. C. Beck. 2001. *The Attention Economy: Understanding the New Currency of Business*. Harvard Business School Press, Boston, MA.

de Groot, A. M. B. 1989. Representational aspects of word imageability and word frequency as assessed through word association. *J. Experiment. Psych. Learn., Memory, Cognition* **15**(5) 824–845.

DeSanctis, G. 1984. Computer graphics as decision aids: Directions for research. *Decision Sci.* **15**(4) 463–487.

Dholakia, U. M., L. L. Rego. 1998. What makes commercial Web pages popular? An empirical investigation of Web page effectiveness. *Eur. J. Marketing* **32**(7–8) 724–736.

Dodds, W. B., K. B. Monroe, D. Grewal. 1991. Effects of price, brand, and store information on buyers' product evaluations. *J. Marketing Res.* **28**(3) 307–319.

Dolgenos, P. 1996. Keys to an effective Web presence. *InfoWorld* **18**(19) 88–89.

Duncan, J., G. W. Humphreys. 1989. Visual search and stimulus similarity. *Psych. Rev.* **96**(3) 433–458.

Eysenck, W. M., M. T. Keane. 1995. *Cognitive Psychology: A Student's Handbook*, 3rd ed. Psychology Press, Hove, U.K.

Folk, C. L., R. W. Remington, J. C. Johnston. 1992. Involuntary covert orienting is contingent on attention control settings. *J. Experiment. Psych. Human Perception Performance* **18**(4) 1030–1044.

Girelli, M., S. J. Luck. 1997. Are the same attentional mechanisms used to detect visual search targets defined by color, orientation, and motion? *J. Cognitive Neuroscience* **9**(2) 238–253.

Glazer, R. 1998. From the editors: The illusion of privacy and competition for attention. *J. Interactive Marketing* **12**(3) 2–4.

Hillstrom, A. P., S. Yantis. 1994. Visual motion and attentional capture. *Perception Psychophysics* **55** 399–411.

James, W. 1950. *The Principle of Psychology*, Vol. 1. Dover, New York.

Jarvenpaa, S. L. 1989. The effect of task demands and graphical format on information processing strategies. *Management Sci.* **35**(3) 285–303.

Jarvenpaa, S. L., G. W. Dickson. 1988. Graphics and managerial decision-making: Research-based guidelines. *Comm. ACM* **31**(6) 764–774.

Jarvenpaa, S. L., T. A. Todd. 1996–1997. Consumer reactions to electronic shopping on the World Wide Web. *Internat. J. Electronic Commerce* **1**(2) 59–88.

Jonides, J. 1981. Voluntary versus automatic control over the mind's eye's movements. John Long, Alan Baddeley, eds. *Attention and Performance IX*. Lawrence Erlbaum, Hillsdale, NJ, 187–203.

Jonides, J., S. Yantis. 1988. Uniqueness of abrupt visual onset in capturing attention. *Perception Psychophysics* **43** 346–354.

Joseph, J. S., L. M. Optican. 1996. Involuntary attentional shifts due to orientation differences. *Perception Psychophysics* **58** 651–665.

Kahneman, D. 1973. *Attention and Effort*. Prentice-Hall, Englewood Cliffs, NJ.

Kerlinger, F. N. 1992. *Foundations of Behavior Research*, 3rd ed. Harcourt Brace College Publishers, New York.

Kieras, D. E., S. D. Wood, D. E. Meyer. 1997. Predictive engineering models based on the EPIC architecture for a multimodal high-performance human-computer interaction task. *ACM Trans. Comput.-Human Interaction* **4**(3) 230–275.

Kirk, R. E. 1995. *Experimental Design: Procedures for the Behavior Sciences*. Brooks/Cole, Pacific Grove, CA.

Lachman, R., J. L. Lachman, E. C. Butterfield. 1979. *Cognitive Psychology and Information Processing: An Introduction*. Lawrence Erlbaum, Hillsdale, NJ.

Lamy, D., Y. Tsal. 1999. A salient distractor does not disrupt conjunction search. *Psychonomic Bull. Rev.* **6**(1) 93–98.

Large, A., J. Beheshti, A. Breuleux, A. Renaud. 1994. Multimedia and comprehension: A cognitive study. *J. Amer. Soc. Inform. Sci.* **45**(7) 515–528.

Li, H., J. L. Bukovac. 1999. Cognitive impact of banner ad characteristics: An experimental study. *Journalism Mass Comm. Quart.* **76**(2) 341–353.

Lim, K. H., I. Benbasat. 2000. The effect of multimedia on perceived equivocality and perceived usefulness of information systems. *MIS Quart.* **24**(3) 449–471.

Mackinlay, J. D., G. G. Robertson, R. DeLine. 1994. Developing calendar visualizers for the information visualizer. *Proc. 7th Annual ACM Sympos. User Interface Software Tech.*, Marina del Rey, CA, ACM Press, 109–118.

Marshall, C., C. Nelson, M. M. Gardiner. 1987. Design guidelines. M. M. Gardiner, B. Christie, eds. *Applying Cognitive Psychology to User-Interface Design*. John Wiley and Sons, New York, 221–278.

McCormick, E. J. 1970. *Human Factors Engineering*. McGraw-Hill, New York.

McFarland, D. 2000. Animation in a flash. *Macworld* **17**(6) 99–101.

McGalliard, K. 1998. Animate your web site GIF graphics. *Editor & Publisher* (May 30) 42–45.

McLeod, P. 1977. Parallel processing and the psychological refractory period. *Acta Psychologica* **41**(5) 381–396.

Navon, D., D. Gopher. 1979. On the economy of the human processing system. *Psych. Rev.* **86** 214–255.

Neisser, U. 1967. *Cognitive Psychology*. Appleton-Century Crofts, New York.

Nelson, D. L., D. J. Bennett, N. R. Gee, T. A. Schreiber, V. M. McKinney. 1993. Implicit memory: Effects of network size and interconnectivity on cued recall. *J. Experiment. Psych. Learn., Memory, Cognition* **19**(4) 747–764.

Nielsen, J. 1995. Guidelines for multimedia on the web. http://www.useit.com/alertbox/9512.html.

Nielsen, J. 1996. Top ten mistakes in web design. http://www.useit.com/alertbox/9605.html.

Nielsen, J. 1997. Changes in Web usability since 1994. http://www.useit.com/alertbox/9712a.html.

Nielsen, J. 2000. *Designing Web Usability*. New Riders, Indianapolis, IN.

Norman, D. A., D. G. Bobrow. 1975. On data-limited and resource-limited processes. *Cognitive Psych.* **7**(1) 44–64.

Nothdurft, H. 1993. Salience effects across dimensions in visual search. *Vision Res.* **33**(5–6) 839–844.

Novak, T. P., D. L. Hoffman, Y. F. Yung. 2000. Measuring the customer experience in online environments: A structural modeling approach. *Marketing Sci.* **19**(1) 22–42.

Park, J., J. Kim. 2000. Contextual navigation aids for two World Wide Web systems. *Internat. J. Human-Comput. Interaction* **12**(2) 193–217.

Pashler, H. 1988. Cross-dimensional interaction and texture segregation. *Perception Psychophysics* **43** 307–318.

Quillian, M. R. 1969. The teachable language comprehender: A simulation program and theory of language. *Comm. ACM* **12**(8) 459–476.

Rewick, J. 2001. E-commerce (a special report): Overview—Choices: A look at the pros and cons of various types of web advertising. *Wall Street J.* (April 23) R12.

Samu, S., S. Krishnan, R. E. Smith. 1999. Using advertising alliances for new product introduction: Interactions between product complementarity and promotional strategies. *J. Marketing* **63**(1) 57–74.

Sharples, H. 1999. How animation boosts sales at e-commerce sites. *Graphic Arts Monthly* **71**(6) 116.

Singh, S. N., N. P. Dalal. 1999. Web home pages as advertisements. *Comm. ACM* **42**(8) 91–98.

Smith, P. A., I. A. Newman, L. M. Parks. 1997. Virtual hierarchies and virtual networks: Some lessons from hypermedia usability research applied to the World Wide Web. *Internat. J. Human-Comput. Interaction* **47** 67–95.

Smith, S. L., N. C. Goodwin. 1971. Blink coding for information display. *Human Factors* **13**(3) 283–290.

Smith, S. L., N. C. Goodwin. 1972. Another look at blinking displays. *Human Factors* **14**(4) 345–347.

Spool, J. M., T. Scanlon, C. Snyder, W. Schroeder, T. DeAngelo. 1999. *Web Site Usability: A Designer's Guide*. Morgan Kaufmann Publishers, San Francisco, CA, 89–91.

Stewart, T. F. M. 1976. Displays and the software interface. *Appl. Ergonomics* **7**(3) 137–146.

Taylor, S. E., S. T. Fiske. 1978. Salience, attention, and attribution: Top of the head phenomena. *Adv. Experiment. Soc. Psych.* **11** 249–288.

Taylor, S. E., S. C. Thompson. 1982. Stalking the elusive "vividness" effect. *Psych. Rev.* **89**(2) 155–181.

Theeuwes, J. 1990. Perceptual selectivity is task dependent: Evidence from selective search. *Acta Psychologica* **74**(1) 81–99.

Thomas, B. H., P. Calder. 2001. Applying cartoon animation techniques to graphical user interfaces. *ACM Trans. Comput.-Human Interaction* **8**(3) 198–222.

Till, B. D., T. A. Shimp. 1998. Endorsers in advertising: The case of negative celebrity information. *J. Advertising* **27**(1) 67–82.

Todd, S., A. F. Kramer. 1994. Attentional misguidance in visual search. *Perception and Psychophysics* **56**(2) 198–210.

Tullis, T. S. 1983. The formatting of alphanumeric displays: A review and analysis. *Human Factors* **25**(6) 657–682.

Tuten, T. L., M. Bosnjak, W. Bandilla. 2000. Banner-advertised Web surveys. *Marketing Res.* **11**(4) 17–21.

Umanath, N. S., R. W. Scamell, S. R. Das. 1990. An examination of two screen/report design variables in an information recall context. *Decision Sci.* **21**(1) 216–240.

Van der Heijden, A. H. C. 1992. *Selective Attention in Vision*. Routledge, New York.

Vecera, S. P., M. J. Farah. 1994. Does visual attention select objects or locations? *J. Experiment. Psych. General* **123**(2) 146–160.

Vreede, G. D. 1997–1998. Collaborative business engineering with animated electronic meetings. *J. Management Inform. Systems* **14**(3) 141–164.

Wickens, C. D. 1984. Processing resources in attention. *Varieties of Attention*. R. Parasuraman, D. R. Davies, eds. Academic Press, Orlando, FL, 63–102.

Wolfe, J. M., K. R. Cave, S. L. Franzel. 1989. Guided search: An alternative to the feature integration model for visual search. *J. Experiment. Psych. Human Perception Performance* **15**(3) 419–433.

Wyer, R. S., T. K. Srull. 1989. *Memory and Cognition in Its Social Context*. Lawrence Erlbaum, Hillsdale, NJ.

Yantis, S., H. E. Egeth. 1999. On the distinction between visual salience and stimulus-driven attention capture. *J. Experiment. Psych. Human Perception Performance* **25**(3) 661–676.

Yantis, S., J. Jonides. 1984. Abrupt visual onsets and selective attention: Evidence from visual search. *J. Experiment. Psych. Human Perception Performance* **10**(5) 601–621.

Zhang, P. 2000. The effects of animation on information seeking performance on the World Wide Web: Securing attention or interfering with primary tasks? *J. Association Inform. Systems* **1** 1–28.

Zhang, P., A. Dillon. 2003. HCI and MIS: Shared concerns. *Internat. J. Human-Comput. Stud.* **59**(4) 397–402.