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Orienting Response and Memory for Web Advertisements:

Exploring Effects of Pop-Up Window and Animation

*This study investigated the effects of pop-up windows and animation on online users' orienting response and memory for Web advertisements. All participants (*N = *60) in a mixed-design factorial experiment were exposed to four online portal Web sites, each containing a banner ad that was either animated or static and a pop-up ad that was also either animated or static. Their orienting responses during reception of the online sites were measured via heartbeats using electrocardiogram (ECG). Recall and recognition memory for ads and portal Web sites were measured via a postexposure paper-and-pencil questionnaire. Hypotheses derived from visual attention, motion effect, distinctiveness, bio-informational, and limited-capacity theories were tested. The results fully supported the proposition that pop-up ads elicit orienting responses. Ad recognition was lower whereas ad recall was higher for pop-up ads compared to banner ads. In addition to main effects, the data revealed several interaction effects, with implications for theory.*

Keywords: *pop-up ads; animation; orienting response; ad recall; ad recognition; limited-capacity theory; distinctiveness theory; motion effects; bio-information theory; new media effects; psychology of technology; Web advertisements; structural features; formal features*

With the rise in interactive interfaces that offer Web users enhanced opportunities for controlling their surfing, and recent increases in online advertising clutter (Napoli, 1999), the competition for gaining user attention on the

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Web has intensified. Advertisers have responded to this challenge by bombarding online users with various kinds of visual and auditory cues, such as larger sizes, brighter colors, animations, recorded voices, and music, in an attempt to capture and sustain viewers' attention to their particular banner advertisements.

This wide application of formal features and structural cues in Web ads makes it difficult to identify those stimulus attributes that are capable of eliciting involuntary attention. However, systematic empirical research in recent years has shown that at least some of these cues have powerful psychological effects. For example, animated ads, one of the most popular attention-grabbing devices used on the Internet, have been shown to elicit orienting responses (Lang, Borse, Wise, & David, 2002) and physiological arousal (Heo & Sundar, 2000). Ad position, an important formal characteristic in print media, also appears to have physiological and psychological effects on user responses to Web ads (Heo & Sundar, 2001).

However, much of the literature on Web advertising to date, including the above-mentioned studies, concerns the most popular advertising type in use today—banner ads. With the growth of the Web as a major medium for mass advertising, more innovative types of ad formats have been developed, such as larger interactive ads, HTML e-mail, and streaming pop-up ads. Among these, the most controversial ad format is the pop-up, given the mix of its popularity and irritation potential (Kamp, 2001). A pop-up ad consists of a small window that pops up over the main browser window and contains text, graphics, and any other information designed to enhance advertising effectiveness. This small window can jump into sight when one enters a site, browses a site, and sometimes when leaving it (Beard, 2001). Pop-up ads are considered to be the most annoying type of advertisement by online users (Coursey, 2001), although it's unclear if this sentiment is shared by the larger Web community (Kamp, 2001). Industry analysts have widely speculated that pop-up ads are enormously effective in attracting user attention (e.g., Beard, 2001; Kamp, 2001); however, so far there is little, if any, public empirical research concerning the effectiveness of this controversial type of advertising. Especially surprising is the lack of empirical research pertaining to the potential effect of a pop-up window in conjunction with the presence of banner ads on the same Web page, even though banner ads and pop-up ads coexist on a large number of portal Web sites. Their widespread use clearly merits exploration of their effects on users.

The current study represents an attempt in this direction. Specifically, it examined the direct and combined effects of one structural feature (animation) and one formal feature (pop-up window)[2] on online users' attention to Web ads, as indicated by orienting response (OR) and memory. This article

first reviews the literature concerning OR, explores theoretical linkages between animation/pop-up window and OR as well as user memory for content, and derives a series of hypotheses. It then presents the methods and results of an experiment designed to test the hypotheses. Finally, it discusses practical and theoretical implications of the findings and offers suggestions for future research.

Literature Review

OR was first proposed by Pavlov (1927) to describe a reflex that causes an immediate response in organisms to a change of their environment. Sokolov (1963) presented another theoretical view of OR. According to him, a repertoire of mental representations for perceived stimuli resides in the cortex of the brain. When an incoming stimulus fails to find a match with the existing neuronal models, an OR occurs. Proceeding from an information-processing perspective, Ohman (1979) further developed Sokolov's idea and proposed a model of OR that is closely related to contemporary theories of attention and memory. According to this model, OR occurs when the search for a mental representation in short-term memory (STM) fails. This OR induces a call for information-processing resources that facilitate a further search in long-term memory (LTM). This cognitive effort eventually leads to registration of the novel stimulus in LTM.

Modern experimental studies of attention in media psychology regard OR as a short-term attention reaction evoked by certain categories of stimuli, for which the resulting response is composed of "an organized set of behavioral and physiological responses" (Lang, 2000, p. 55). Those stimuli that have the potential to elicit OR may be categorized as follows: novel, moving, meaningful, or surprising. The physiological changes that occur when an organism encounters a novel stimulus include pupil dilation (Lynn, 1966), increased skin conductance (Lang, 1995; Ohman, 1979; Sokolov, 1963), decreased alpha waves in the brain (Lynn, 1966; Reeves, Thorson, & Schleuder, 1986), and a reduced heart rate (Graham, 1979; Lacey & Lacey, 1974; Lang, 1995; Sokolov & Cacioppo, 1997).

Pop-Up Window and OR

Typically pop-up ads come into sight after the main Web page has fully downloaded, even though oftentimes the downloading technically occurs while the user is moving from one page to another, slowing download speed surreptitiously (e.g., Kamp, 2001). The appearance of a pop-up window creates a sudden change in the visual field. The visual effect of such an unexpected

stimulus can be explained by visual attention theory, particularly selective attention processes.

Numerous studies in psychology lend support to the claim that stimuli with abrupt visual onsets capture involuntary attention, that is, in a stimulus-driven manner (Gibson & Kelsey, 1998; Jonides, 1981; Jonides & Yantis, 1988; Lambert, Spencer, & Mohindra, 1987; Muller & Rabbitt, 1989; Nakayama & Mackeben, 1989; Yantis & Hillstrom, 1994; Yantis & Johnson, 1990; Yantis & Jones, 1991; Yantis & Jonides, 1984, 1990, 1996). A possible neural mechanism is proposed to explain the visual control by abrupt onset. The so-called sustained-transient model assumes that the visual system consists of two parallel channels. Sustained channels serve to transmit figural information, whereas transient channels transmit information about location or rapid changes in location (Ikeda & Wright, 1972). With the sudden onset of stimuli, those transient channels in the primary visual system respond selectively. In contrast to no-onset stimuli, objects exhibiting abrupt onset cause transient channels to transmit these signals to the brain and receive immediate visual attention (Breitmeyer & Ganz, 1976; Phillips & Singer, 1974; Todd & Van Gelder, 1979; Yantis & Jonides, 1984). In light of this theory, we may predict that transient channels would selectively respond to the pop-up window as a stimulus with abrupt onset, toward which visual orientation is directed.

An alternative explanation for attentional capture by abrupt onset lies in the object-based theories of visual attention (Duncan, 1984; Kahneman, Treisman, & Gibbs, 1992; Kanwisher & Driver, 1992). According to these theories, various stimuli in the visual domain are regarded as objects, and it is the object status that determines the allocation of attention. When a new stimulus appears, a corresponding object file needs to be created. This creation process leads to direction of attention toward this new object. This theory has adaptive significance, in that "new objects are likely to have behavioral significance and to require rapid and accurate identification and response" (Yantis & Jonides, 1996, p. 1506). Given this rationale, the abrupt onset of a pop-up window on the computer screen will prompt a new representation for this object and demand immediate visual attention.

Along the same lines, the limited-capacity model of mediated message processing in communication research provides another theoretical reason for predicting that pop-up windows will elicit OR. This model assumes that converting an environmental stimulus to a mental representation involves three subprocesses: encoding, storage, and retrieval (Lang, 2000). The selective process of what information will be encoded is determined by two factors. One is the relevance of message content, and the other is the presentational feature of the message. This model suggests that novel and unexpected stimuli are more likely to engage the sensory receptor and evoke involuntary atten-

tion. The sudden onset of pop-up windows presumably prompts a change in the visual domain and is regarded as a novel and unexpected stimulus that elicits automatic orientation. Therefore, this model would predict the OR-eliciting property of pop-up windows.

Based on the preceding evidence and rationale, the following hypothesis concerning the effect of pop-up windows on orienting response is proposed:

Hypothesis 1: Individuals will exhibit orienting responses with the sudden onset of pop-up windows.

Animation and Orienting Response

Animation is the process of creating and displaying the illusion of movement by manipulating, successively and at a certain rate, minutely different individual states of continuing action (Magnenat-Thalmann & Thalmann, 1996). The rapid development of Internet technology has made the display of animated images on a computer screen a possibility. In a very short time, animation has become the favorite visual cue among online advertisers, who seem to assume that it can catch viewers' attention and increase click-through rate (Cleland & Carmichael, 1997).

Despite its increasing popularity with online advertising, only a few empirical studies have investigated the physiological effects of ad animation. Results from two studies suggest that animated banner ads elicit OR while static ads do not (Heo & Sundar, 2000; Lang, Borse, et al., 2002). Previous studies of television led to the same conclusion: moving pictures, in contrast to still images, induce greater physiological arousal (e.g., Detenber & Reeves, 1996; Lang, Dhillon, & Dong, 1995). Several theoretical frameworks have been proposed to explain the OR-eliciting property of motion, such as motion-effect theories (Reeves & Nass, 1996), distinctiveness theories (Gati & Tversky, 1987; Nairne, Neath, Serra, & Byun, 1997) and the bio-informational theory of emotion (Detenber & Reeves, 1996).

Motion-effect theories. Motion-effect theories assume that human beings possess an inherent predisposition toward moving objects. Motion, one of the fundamental attributes of the physical world, means threats or opportunities to human beings in an adaptive sense (Reeves & Nass, 1996). There are specialized nerve cells developed in our brain to detect and process motion (Goldstein, 1989); that is, in the presence of moving images, people tend to focus their attention on the source of the motion. The visual orientation toward motion, together with the resulting physical reactions, prepares human beings to process relevant information. In the context of the current

study, animated ads represent moving stimuli and, therefore, presumably would prompt viewers' visual orientation and lead to commensurate physiological changes. Several studies in Web advertising and television, as previously mentioned, have provided empirical support for this proposition. In addition, several mass communication research findings have provided additional evidence of an association between the presence of cuts, edits, and movement in television commercials and OR among TV viewers (Lang, Bolls, Potter, & Kawahara, 1999; Lang, Geiger, Strickwerda, & Sumner, 1993; Reeves, Thorson, Rothchild, McDonald, Hirsch, & Goldstein, 1985). All of this suggests that animated images are capable of eliciting OR.

Distinctiveness theories. Distinctiveness theories posit that if certain attributes of a stimulus make it different from all other elements in the visual domain, that is, produce a distinctive effect, this stimulus is in an advantageous position to attract and hold viewers' attention (Gati & Tversky, 1987; Nairne et al., 1997). In other words, people tend to orient toward those visual cues that distinguish the stimulus from its immediate environment and make it stand out. According to this theory, certain structural and formal features of mediated messages can elicit the distinctiveness effect and, thereby, direct viewers' visual attention to a certain message. Researchers working with print and television stimuli have identified many layout features, such as color, size, vividness, and motion, as distinct characteristics that serve as OR-eliciting devices (Beattie & Mitchell, 1985; S. E. Taylor & Thompson, 1982).

In the context of Web advertising, the motion property of animation distinguishes the animated ads from the still text or images on the same screen. When Web users are exposed to such a stimulus, the standout effect of moving objects in the visual domain theoretically attracts their immediate attention. Although previous studies based on distinctiveness theories of motion have not examined Web users' orienting responses, it is reasonable to speculate that embedding animated ads in the still background page will reveal the distinctiveness of animation (or motion property) that captures online viewers' attention.

The bio-informational theory of emotion. In contrast to other approaches to emotion, the bio-informational theory regards emotion as action dispositions and proposes a network model of emotion (Lang, 1995). According to this theory, there are special nodes in the human brain that correspond to attributes of emotion-eliciting stimuli. In the presence of those attributes, the corresponding nerve cells are activated, and through the neural pathways,

the signals are sent to the biological system that regulates the readiness for action, that is, emotion (Detenber & Reeves, 1996). In other words, this theory posits a clear link between certain characteristics of a stimulus and the activation and preparation for action as demonstrated by physiological responses.

Based on this theoretical rationale, it is important for researchers to examine those stimulus characteristics associated with nodes in the emotion network. At least one empirical study has indicated the emotion-eliciting property of moving images (Detenber & Reeves, 1996), suggesting the existence of special nodes in the emotion network that are associated with motion. Therefore, it is expected that animated ads on a computer screen activate online users' nodes for motion and initiate a disposition for action, as demonstrated by a physiological response of visual orientation. In light of the preceding evidence and rationale, the following hypotheses concerning the effect of animation on orienting response are proposed.

Hypothesis 2a: Individuals who view animated banner ads will exhibit orienting responses.

Just as there are strong theoretical reasons to predict the OR-eliciting ability of animated banners, there is some empirical evidence to suggest that static banners do not elicit OR. For example, Lang, Borse, et al. (2002) showed that even stand-alone static banner advertisements did not elicit orienting, implying that on an actual Web page with greater informational competition, the attention-getting potential of these ads is further diminished. Furthermore, the presence of a static banner at the top of a Web page can hardly be considered novel. Therefore, we would expect no OR for static banners in the current study.

Hypothesis 2b: Individuals who view static banner ads will not exhibit orienting responses.

Hypothesis 3: Individuals who view animated pop-up ads will exhibit stronger orienting responses than those who view static pop-up ads.

Pop-up ads may be considered a novel piece of stimulus in comparison to traditional banner ads—not just because pop-ups are relatively recent but also because they appear on the computer screen in an unexpected manner, without the user's consent (Beard, 2001). Furthermore, although banner ads are placed at the top (or along the side) of the Web page without obstructing the main page, pop-up ads are "in your face" and come into sight in front of the main browser leading to a higher degree of stimulus significance. Therefore,

the theories reviewed thus far would lead us to the following prediction of the relative involuntary attention evoked by banner and pop-up ads.

Hypothesis 4a: Individuals will exhibit stronger orienting responses with the sudden onset of animated pop-up windows than with the onset of animated banner ads.

Hypothesis 4b: Individuals will exhibit stronger orienting responses with the sudden onset of static pop-up windows than with the onset of static banner ads.

OR and the Allocation of Cognitive Resources

The limited-capacity model of mediated message processing (Lang, 1992, 1995, 2000; Lang & Basil, 1998) offers a theoretical framework suitable for explaining the direct and combined effects of animation and pop-up windows on memory of advertisements. This model assumes that, as information processors, people have a fixed amount of cognitive resources. Three subprocesses are involved in processing the mediated message: encoding, storage, and retrieval. The encoding subprocess determines what elements of the original environmental stimulus will be transformed into mental representations. This selective process is either controlled (in the sense that message receivers deliberately pay attention to some aspects of the message based on their goals), or automatic (as when certain attributes of the message content itself evoke receivers' involuntary attention). The storage subprocess refers to the continuing process of relating the newly encoded information to previous memories stored in the brain. This associative network of memory indicates that the more the links are established between new and old information, the better the message is stored. The retrieval subprocess serves to reactivate the stored mental representations in working memory. In principle, the limited processing resources that a message recipient possesses are allocated independently to the three subprocesses. This theoretical assumption leads to the fact that an increase in resource allocation to one subprocess will result in a decrease of available resources for other concurrent subprocesses. Therefore, the identification of factors that affect the allocation of resources to different subprocesses is of particular importance in message processing.

This model suggests that ORs are one of the automatic mechanisms that influence the level of resources allocated to the different subprocesses. As previously mentioned, the nature of message content and structural features can evoke the automatic selective process, that is, OR. The OR, in turn, causes an automatic allocation of processing resources to encode the stimuli that

elicit the OR. This increase of resources at the encoding level leaves fewer resources available for other simultaneous subprocesses, namely storage and retrieval. Such variations in message processing at different levels lead to different degrees of memory. According to this theory, measures of recognition index whether information is encoded, whereas measures of cued recall index the thoroughness of storage, and measures of free-recall index retrieval.

In the current study, two presentation features—animation and pop-up windows—are expected to affect the memory of Web advertisements. Before elaborating and proposing the potential effect of these attributes on ad memory, however, it is important to mention the particular experimental setting of the current investigation. Participants in the study browsed four different portal Web pages on a computer screen. Each Web page was accompanied by a banner ad, either animated or static, and positioned at the top. Also embedded within each portal Web page was a pop-up ad, either animated or static. Each participant was randomly assigned to view one of the four versions of presentation (AA – animated banner ad + animated pop-up ad; AS – animated banner ad + static pop-up ad; SA – static banner ad + animated pop-up ad; SS – static banner ad + static pop-up ad).

Previous reviews of research concerning the effects of motion and objects with abrupt onset on ORs suggest that animation and pop-up windows elicit ORs. This OR, according to the limited-capacity theory, will evoke an automatic increase of resource allocation to encoding the stimulus that elicits the OR. In the context of the current study, for reasons discussed earlier, a Web page with animated banners and animated pop-up ads would elicit more frequent ORs than other stimulus versions. Therefore, a greater level of processing resources is allocated to the encoding subprocess, which, in turn, results in a lesser amount of resources available for storage and retrieval. According to Lang (2000),

> To the extent that a message elicits frequent orienting responses, there will be frequent calls for processing resources to encode the message, which may cause a disproportionate amount of processing resources to be automatically allocated to the encoding subprocess. This will decrease the amount of resources that are unallocated and therefore available to be allocated to storage. (p. 53)

This rationale led to the prediction that the AA version of the stimulus would receive the highest scores for ad recognition and the lowest score for ad recall. On the other hand, exposure to the SS version would likely be the least cognitively demanding (for encoding purposes) as a result of the ab-

sence of animation and thereby make more resources available for storage and retrieval compared with other versions of stimuli, in which at least one ad was animated. Given the preceding rationale, the following hypotheses concerning the combined effect of animation condition and pop-up window on ad memory emerged:

Hypothesis 5a: The score for ad recognition will be highest when pop-up ads and banner ads are animated, will be lowest when pop-up ads and banner ads are static, and will be in-between when pop-up ads and banner ads are not of the same ilk.

Hypothesis 5b: The score for ad recall will be lowest when pop-up ads and banner ads are animated, will be highest when pop-up ads and banner ads are static, and will be in-between when pop-up ads and banner ads are not of the same ilk.

Predicted outcomes for these hypotheses are illustrated in Figure 1:

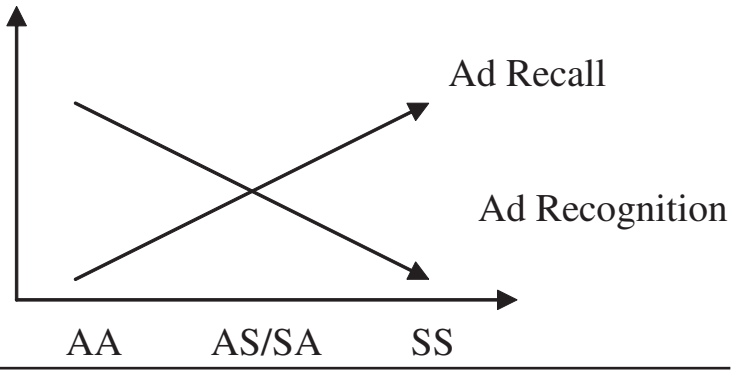


Figure 1. Hypothesized Pattern of Ad Memory as a Function of Animation Condition and Ad Type

Based on the expected superiority of pop-up ads over banner ads, the following hypotheses concerning the effect of ad type on ad memory are proposed.

Hypothesis 6a: Ad recognition for pop-up ads will be higher than for banner ads.

Hypothesis 6b: Ad recall for pop-up ads will be lower than for banner ads.

Method

To examine the direct and combined effects of animation and pop-up window on online users' ORs and memory of Web advertisements, a $4 \times 2 \times 4 \times 8$ mixed-design factorial experiment was conducted, with animation condition as a between-participants variable and type of Web advertisement (banner ad vs. pop-up ad) as a within-participants variable. In the current study, four versions of presentation of animation were used: AA – animated banner ad + animated pop-up ad; AS – animated banner ad + static pop-up ad; SA – static banner ad + animated pop-up ad; SS – static banner ad + static pop-up ad. The first independent variable, animation condition, then had four levels: AA, AS, SA, and SS. The second independent variable, ad type, had two levels: banner ad or pop-up ad. To increase the generalizability of our findings, each participant was exposed to four different Web sites, each with a banner and a pop-up ad. The third independent variable, site ID, had four levels: Site A, Site B, Site C, and Site D. The fourth independent variable, time, had eight levels, ranging from Second 1 to Second 8.

There were two dependent variables: orienting response and ad memory. OR was monitored via heart-rate measures throughout the test period while ad memory was measured with a postexposure paper-and-pencil questionnaire.

Design Overview

All participants ($N = 60$) browsed four different portal Web pages on a computer screen. Each Web page was accompanied by a banner ad, either animated or static, and positioned at the top. Also embedded within each portal Web page was a pop-up ad, either animated or static, and positioned either on the left (the first two Web pages) or on the right (the next two Web pages). The Appendix shows all four sites used in the experiment. Each participant was randomly assigned to view ads in one of four animation conditions (AA, AS, SA, or SS). To minimize order effects, the four Web pages were shown to different participants in one of four different orders. Throughout the procedure, participants' cardiac activity was recorded via electrocardiogram (ECG) to determine the occurrence and strength of ORs. After exposure to all four Web sites, participants completed a questionnaire designed to test ad recall and recognition as well as to gather basic information about computer use and demographics.

Participants

Sixty male and female undergraduate students enrolled in communication classes participated in the current study in exchange for class credit. The project announcement indicated that the study involved an examination of psychological and physiological responses to Web-site content, and that participants will be asked to browse the Web pages as they would normally do on a Web site. Students interested in the project signed up for a particular time slot on a sign-up sheet and were told that they would be contacted by the researcher to confirm their participation in the study. After all sign-up sheets were collected, participants were randomly assigned to either the AA, AS, SA, or SS condition. All participants signed an informed consent form prior to their participation in the experiment.

Stimulus Material

Four different Web pages were created for this study (see the Appendix). To increase external validity, all the ads and portal Web pages used in this experiment were obtained from existing commercial Web sites. The eight stimulus ads used were different in product type, and the four portal sites were highly trafficked Web sites. In selecting the stimulus ads, a pool of ads featuring different product categories was downloaded. Then, based on the literature on product involvement, eight stimulus ads featuring high-involvement products for the intended participant population were selected (e.g., Heo & Sundar, 2000; Zaichkowsky, 1985). The products included MP3 player, airline ticket, credit card, computer monitor, wireless service, computer drives, long distance service, and printer.

The animated ads had either text or images that moved or were flashing after the loading, whereas the still ads had no moving objects or text. (For all ads in the current study, the animated version was downloaded from the Web, and the static version of the same ad was created by disassembling the parts and rendering the ad into a still image, using Adobe Photoshop).

Dependent Variables

OR. A physiological measure of heart activity (electrocardiograph—ECG) was employed to detect the occurrence and strength of orienting responses. ECG is a method of recording the electrical impulses that pass through the heart during contraction and spread to the surface of the body (Andreassi, 2000). The time between beats, called the inter-beat interval (IBI), is recorded and then converted into beats per minute (BPM) by dividing 60 by IBI. In the

current study, a transducer was used to detect the physiological signal from the surface of the skin (in this case, three 1-3/8″ vinyl electrodes with pinch connectors were attached to the respondents, one on the wrist and one each on right and left ankles, just above the ankle bone) and transmit that signal to the amplifying system, which then transmitted it to a recording computer. The hardware used in the experiment was manufactured by Biopac, and the filter was set to a low pass, 66.5 Hz (with the equipment registering a gain of 2,000).

Through the years, a growing body of evidence has demonstrated that the occurrence of an OR is accompanied by a decrease in heart rate beginning immediately after the orientation-eliciting stimulus and continuing for about 4 to 6 seconds (Campbell, Wood, & McBride, 1997; Graham & Clifton, 1966; Lang, 1990, 2000; Lang, Borse, et al., 2002). This tendency has surfaced in a number of studies conducted in a variety of settings, including ones dealing with heart-rate slowdowns in response to scene changes, movement, and commercial onsets during television viewing (Lang, 1990; Reeves & Nass, 1996; Thorson & Lang, 1992), heart-rate deceleration when using relatively low-intensity sounds (Turpin & Siddle, 1983), and eye bursts in REM sleep (W. B. Taylor, Moldofsky, & Furedy, 1985). In light of this empirical evidence, ECG seems to be the most appropriate method for collecting heart-rate data, and thereby detecting ORs toward the presentation features under study, namely, animation and type of advertisement (banner vs. pop-up window).

Ad memory (recognition/recall). The dependent variable of ad memory was measured in terms of free recall and recognition. Free recall, the less-sensitive measure of memory, indicates how well a person can retrieve a piece of information without any cues. Recognition, in contrast, is a more sensitive measure of memory, in that the information to be recognized is presented along with foils and contains many cues to help the person retrieve the correct information (Tulving, 1979; Tulving & Thompson, 1973).

In the current study, recognition memory was operationalized in the form of 12 multiple-choice items in a questionnaire. Those questions were written for the eight ads to reveal whether participants remembered seeing some key elements of the ads ranging from product categories to product name (e.g., "Which of the following products was advertised on one of the Web pages you visited today?" and "Which of the following credit cards was advertised on one of the Web pages you visited today?"). In addition, participants received a list of company Web sites, including foils, and asked to indicate whether they remembered having seen them during the browsing. All questions were about headlines or animated words in the ads that could be easily encoded. None of the questions pertained to details embedded in the text of the ads. Six

of the 12 questions elicited recognition for the four banner ads while the remaining 6 were related to the four pop-up ads across the four sites used in the current study.

For recall memory, participants were asked to list as many ads as they could remember seeing during the exposure to the Web pages. Responses with correct brand names or identification of some details of the ads were coded as "correct." The free-recall question appeared at the beginning of the questionnaire to avoid being influenced by the recognition test.

For recall and recognition memory, a correct answer was scored as 1 and an incorrect answer as 0. For every participant, the cumulative scores for ad recall and ad recognition were used to measure dependent variables in the analyses.

Procedure

The current study was conducted on an individual basis in a laboratory. On arrival, participants were greeted by the investigator and were then informed that the study involved browsing several online Web pages. They were also told that at the end of the browsing, they would receive a questionnaire to complete. Participants were then led to a room that housed the Web-browsing computer and ECG measurement devices. Each participant was seated in a comfortable chair while electrodes were placed on his or her wrist and ankles and the experimental procedure was introduced. After giving the first verbal experimental instruction regarding general procedure for the experiment and receiving written consent from each participant, the investigator went into another room to check whether the equipment was producing appropriate readings. Participants were then instructed to turn on the computer monitor and browse the instruction page on the computer screen. For all participants, the first instruction reads

Welcome to the Study!

The next few screens will display the homepages of some popular portal Web sites. Please read each screen as you would normally read a Web page. Each screen will stay on the computer monitor for *ONLY A FEW SECONDS*. Therefore, *PLEASE DO NOT USE YOUR MOUSE* unless instructed.

DO NOT CLICK ON THE LINKS. DO NOT SCROLL DOWN.
Click **HERE** to Start and take your hands off the mouse.

The word *HERE* was highlighted as a hyperlink to connect the participant to the next Web page for the experiment. Although participants were reading

the instruction, the investigator went to the other room to perform baseline recording for a period of 30 seconds. When finishing the baseline recording, the investigator returned and asked participants to count up to 10 and then click the hyperlinked word to initiate the activities they were to perform. During that brief period of time, the investigator went back to the other room and waited for the participant to begin.

Immediately after clicking on HERE to begin the experiment, participants were automatically linked to the first portal Web page. As soon as the portal screen was displayed, the investigator, who could monitor browsing activity on a remote screen in the observation room, initiated the recording of ECG. For the rest of the experiment, participants were not allowed to use the mouse or keyboard. All copies of graphic image format (GIF) files and HTML pages were stored in the Web browser's cache to ensure immediate appearance of images and text.

After 15 seconds, a pop-up window appeared on the screen. Twenty-five seconds later, participants were led via the HTML refresh-content command to the second Web page. Fifteen seconds after this second Web page loaded on the screen, participants saw another pop-up ad and were led to the third page 25 seconds later. Each page stayed on the screen for 40 seconds. After they had gone through all four pages, participants were asked to complete a questionnaire. On completing the questionnaire, participants were debriefed and thanked for their participation.

Data Analysis

To test the hypotheses, two separate data sets were created, one housing the physiological response and the other containing all the psychological responses.

In the physiological data set, for each participant, information about animation condition, ad type, site ID, time, and BPM change (BPM change = BPM value/second – baseline measure [i.e., the second immediately preceding the stimulus]) was recorded. Given that an OR usually occurs during the first few seconds after the onset of a stimulus, the BPM change scores for the first 8 seconds after the onset of each of the eight ads (four banner and four pop-up ads) were used in the statistical analysis. A four-way ANOVA was used to detect the direct and combined effects of animation condition, ad type, site ID, and time on BPM change.

Theoretically it is expected that the various animation conditions (AA, AS, SA, SS) would have differential effects on OR and ad memory, which leads to a $4 \times 2 \times 4 \times 8$ mixed-factorial design in the current study. To test Hypotheses 2 through 4, two broad categories of animation conditions (i.e., animated vs.

Table 1
BPM Change as a Function of Animation Condition, Ad Type, Site ID, and Time

Source	*df*	*df* of the Denominator Term	Sum of Squares	*F* Ratio
Animation condition	3	56	44.67	0.26
Ad type	1	3,720	7,282.82	126.94***
Site ID	3	3,720	1,205.78	7.01***
Ad Type × Site ID	3	3,720	1,304.00	7.58***
Ad Type × Animation Condition	3	3,720	873.74	5.08***
Site ID × Animation Condition	9	3,720	4,243.53	8.22***
Ad Type × Site ID × Animation Condition	9	3,720	1,518.50	2.94***
Time	1	3,720	76.90	1.34
Ad Type × Time	1	3,720	41.19	0.72
Site ID × Time	3	3,720	34.11	0.20
Ad Type × Site ID × Time	3	3,720	43.99	0.26
Time × Animation Condition	3	3,720	40.10	0.23
Ad Type × Time × Animation Condition	3	3,720	124.35	0.72
Site ID × Time × Animation Condition	9	3,720	388.63	0.75
Ad Type × Site ID × Time × Animation Condition	9	3,720	379.28	0.73

Note. BPM = beats per minute.
***$p < .001$.

static) were computed by collapsing the cardiac response curves for animated ads (animated banner in AA and AS condition and animated pop-up in AA and SA condition) and static ads (static banner in SA and SS condition and static pop-up in AS and SS condition).

In the psychological data set, for each participant, information about animation condition, ad type, ad recall, and ad recognition was included. Given that there were two types of advertisements (banner ad vs. pop-up ad), ad recall and recognition for each ad type was recorded separately. A two-way ANOVA was used to detect direct and combined effects of animation condition and ad type on ad recall and ad recognition.

Results

Given that animation condition was a between-participants variable, and ad type, site ID, and time were within-participants variables, a four-way mixed ANOVA was used to test the potential effect of animation condition, ad type, site ID, and time on BPM change. The analysis yielded two main effects, three significant two-way interaction effects, and one significant three-way interaction effect (see Table 1).

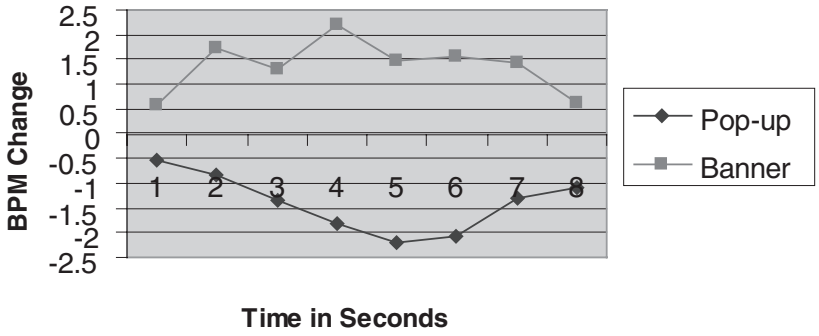


Figure 2. Beats-Per-Minute Change as a Function of Ad Type and Time

Hypothesis 1 predicts the occurrence of OR with the onset of pop-up windows. More specifically, a deceleration of BPM change was expected in response to the arrival of the pop-up window on the screen. The four-way ANOVA on BPM change revealed a main effect for ad type, $F(1, 3720) = 126.94$, $p < .001$, and the visual inspection of Figure 2 clearly suggests that when pop-up ads appeared on the screen, a significant deceleration of BPM occurred for the first 4 to 5 seconds followed by an acceleration back toward the baseline. However, in the case of banner ads, there was no deceleration but instead a slight acceleration of heart rate during the first several seconds, and then deceleration back toward the baseline, quite unlike the pattern observed at the onset of the pop-up window, but almost a mirror image of the response for pop-up. Therefore, the onset of pop-up ads elicits ORs while the onset of banner ads does not.

Hypothesis 1 was further tested by conducting a trend analysis of the heart-rate data in the pop-up condition and looking for a significant quadratic component of the time factor. Previous studies involving ORs have shown that the deceleration of heart rate exhibits a U-shape pattern (i.e., a quadratic or cubic component indicative of a monophasic or biphasic trend, respectively) when OR occurs with no verbal information being processed (Brown, Morse, Leavitt, & Graham, 1976; Graham, 1979). The results demonstrate that the cardiac response curve (CRC) exhibited a statistically significant quadratic trend ($t = 2.93$, $p < .01$, see Figure 3). Therefore, Hypothesis 1 was fully supported by the data.

Hypothesis 2a and Hypothesis 2b predict that animated banner ads elicit OR while static banner ads do not. Hypothesis 3 predicts that animated pop-up ads elicit stronger OR than static pop-up ads. The analysis yielded a significant interaction effect between animation condition and ad type, $F(3,$

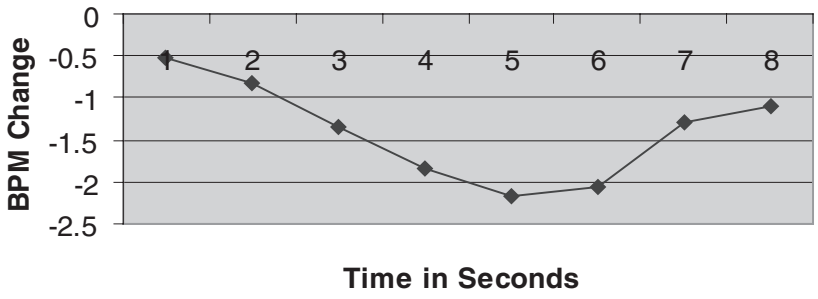


Figure 3. Cardiac Response Curve for Pop-Up Ads

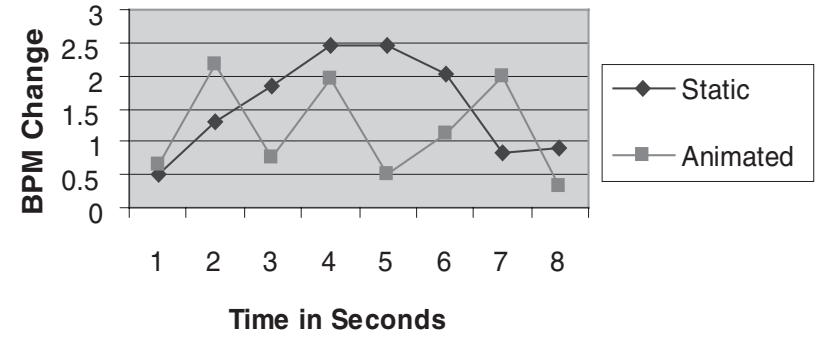


Figure 4. Beats-per-Minute Change for Banner Ads as a Function of Animation Condition

3720) = 5.08, $p < .001$. When the ad type is banner, there appears to be no significant differences between animated ads and static ads in terms of eliciting ORs (see Figure 4). In fact, neither elicited any OR, as BPM changes for animated ads and static ads were above the baseline, with animated ads showing a slightly decelerating trend. Therefore, Hypothesis 2a was not supported, and Hypothesis 2b was supported. In the case of pop-up ads (Figure 5), the BPM changes for animated ads and static ads were below the baseline, with animated pop-up ads eliciting relatively stronger orienting responses (significant quadratic trend, $t = 2.21, p < .05$) than static pop-ups (marginally significant quadratic trend, $t = 1.95$, $p = .05$). Therefore, Hypothesis 3 was supported.

Hypothesis 4a and Hypothesis 4b predict that when holding animation condition constant, pop-up ads will elicit stronger OR than banner ads. Figures 4 and Figure 5 suggest that there are significant differences between pop-up ads and banner ads in terms of heart rate. Animated pop-up ads

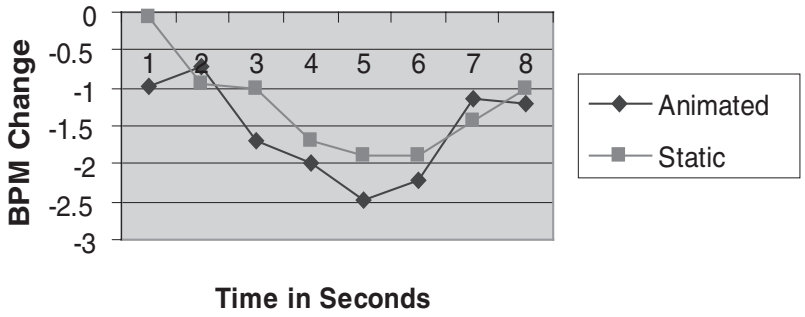


Figure 5. Beats-per-Minute Change for Pop-Up Ads as a Function of Animation Condition

showed a significant quadratic trend ($t = 2.21, p < .05$) while animated banners did not ($t = –0.62, p > .05$). For static ads, pop-ups showed a near-significant decelerating quadratic trend ($t = 1.95, p = .05$) while banners showed a significant accelerating quadratic trend ($t = –2.61, p < .01$). In animated and static conditions, the BPM changes for pop-up ads were below the baseline (showing a significant polynomial trend, as discussed earlier) while the BPM changes for banner ads were consistently above the baseline. Therefore, Hypothesis 4a and Hypothesis 4b were supported.

Hypothesis 5a and Hypothesis 5b predicted a main effect for animation condition on ad memory. A mixed two-way ANOVA, with animation condition as a between-participants variable and ad type as a within-participants variable, showed no main effect of animation condition for either ad recall, $F(3, 56) = 1.52, p = .22$, or ad recognition, $F(3, 56) = .09, p = .96$. Therefore, Hypothesis 5a and Hypothesis 5b were not supported.

However, a significant main effect of ad type was found for ad recall, $F(1, 56) = 21.78, p < .01$, and ad recognition, $F(1, 56) = 7.33, p < .01$. The mean ad recall score for pop-up ads ($M = 1.57$) was higher than that for banner ads ($M = .8$). In contrast, the mean recognition score for pop-up ads ($M = 2.7$) was lower than that of banner ads ($M = 3.4$). In short, ad type, as originally expected, had a significant impact on ad recall and recognition, but in the opposite direction of what was predicted. Therefore, Hypothesis 6a and Hypothesis 6b were not supported. The interaction effects in this two-way mixed ANOVA were not statistically significant.

In addition to the tested effects, the four-way ANOVA on BPM change revealed one more main effect, namely, site ID, $F(3, 3720) = 7.01, p < .001$, as well as interactions involving site ID. Taken together, these results indicate that site content may make a difference to heart-rate change during the course of the interaction.

To summarize, data analyses revealed a significant impact of pop-up window on ORs. The animation effect on OR was nonexistent in the case of banner ads and only subtly apparent in the case of pop-up ads. Message content played an important role in eliciting ORs as demonstrated in various interaction effects. A main effect for animation condition on ad memory did not emerge. A main effect for ad type on ad memory was detected; however, the direction of the means disconfirmed hypothesized expectations.

Discussion

Generally speaking, the physiological data gathered from the experiment were supportive of the hypothesis concerning the OR-eliciting effect of pop-up windows. The psychological data also revealed the superior effect of pop-up windows over the commonly used banners with respect to ad recall. This is consistent with contemporary theories of OR and visual attention, which suggest that people tend to orient automatically toward those mediated messages that are novel and unexpected in the immediate visual domain. The larger implication of this finding is that formal features of media messages can evoke involuntary attention, ORs in particular, not only in traditional media as has been previously demonstrated but also in the new Web environment.

However, the absence of the expected main effect for animation condition (and the insignificant animation/time interaction) on heart-rate change is somewhat disappointing. Prior research on Web advertising has shown that animation can serve as a perceptual cue that captures users' immediate attention and generates involuntary responses during the early stage of information processing. However, this claim emerged from the specific setting of banner ads, which is quite different from the current study where banner ads were used in conjunction with pop-up ads on the same Web page. The addition of pop-ups to the experimental stimulus may have resulted in the negation of the much-touted animation effect. On the other hand, we may speculate that animation may have lost its novelty effect, especially with college students who may have become accustomed to seeing animated ads during their daily Web-surfing experience. Another explanation relates to the nature of the experimental setting. Participants browsed four Web sites in a sequence in the current study. Each contained a banner ad and a pop-up ad that always appeared 15 seconds after the display of the main page. After exposure to the first couple of Web pages, respondents might have a sense of what would appear on the next page and eventually become used to the experimental procedure and stimulus pattern. This kind of expectation could have created a kind of floor effect and an overall lack of attention or OR

toward animated ads (Heo & Sundar, 2001). In fact, the onsets of animated banner ads on the first two sites were separated from the onsets of animated banner ads on the last two sites to further test if ORs to animated banner ads habituate (i.e., habituation effect vs. total absence of OR). The results indicated that there was no orienting response whatsoever to animated banner ads. Therefore, animated ads seem no longer significant enough in the visual domain to attract viewers' attention.

Although it is clear that pop-ups are novel stimuli, we don't know the true psychological status of animation in a complex Web environment. What we do know however is that content, that is, site ID, plays an important role in eliciting ORs. Given that we chose stimulus material that was relevant to college students, Web-site text and ad content may have served as signal stimuli. By adding the site ID variable, the insignificant animation condition effect was rendered statistically significant, which illustrates the importance of both structural features and content aspects in engaging the automatic resource allocation system. A recent study by Lang, Borse, et al. (2002) brought to the fore the importance of considering content when it found that not only animated banners but also textual warnings about one's immediate environment shown on a computer screen (e.g., There is someone behind you!) elicit ORs.

Thus, one could argue that a well-crafted textual message within a banner ad is capable of eliciting ORs even though banners, in general, were found not to significantly affect heart rate in the current study. It must be noted that in the current experiment, banner ads were embedded within and positioned at the top of the Web pages. Although ecologically valid, it makes it difficult to separate the OR to the banner ad from the OR to the onset of the Web page itself. The fact that we did not find any significant orienting toward banners makes this methodological concern somewhat moot; however, more important, it points to a larger implication of this finding, that is, the appearance of the Web page itself (with banner ads embedded at the top) does not elicit an OR.

As for the effects on memory, we found that banner ads had higher ad recognition than pop-up ads, quite contrary to our expectations derived from limited-capacity theory. Our experimental manipulation and procedure may account for this unexpected result: Each of the four Web pages used as stimulus sites in the current study remained on the computer screen for about 40 seconds. The fact that banner ads appeared at the top in the main Web page and pop-up ads appeared 15 seconds after each Web page was fully loaded indicates a relatively shorter on-screen time for pop-up ads (25 seconds) compared to banner ads (40 seconds). Even though pop-up ads elicit ORs, the lon-

ger time span on the computer screen may give banner ads a better chance to be fully encoded, and therefore, improve prospects for ad recognition.

The continuing demand for processing resources at encoding level will generally result in better recognition memory and lead to better storage and retrieval. However, if the encoding demand overloads the cognitive system, then limited capacity theory predicts a decrease in the available resources for other concurrent tasks such as storage and retrieval. Under this circumstance, there may not be enough resources for storing all the information that is encoded. Such a situation could cause a competition for resource allocation among those bits of information that have been encoded. Better recall for pop-up ads in the current study indicates that pop-up ads may not necessarily overload the processing system; however, they certainly seem to command more processing resources for storage and retrieval than banner ads. This raises the question: What underlying mechanisms cause an allocation of more resources to pop-up ads instead of banner ads at the storage (and retrieval) level, even though banners were apparently better encoded than pop-ups? The limited-capacity theory suggests that controlled and automatic processes affect storage. Viewers may deliberately choose to allocate more resources to storage and retrieval to learn and memorize certain message content. Given the research context, in which there is no test or any other requirement concerning message processing for participants, the controlled mechanism is unlikely to be at work here. However, it is reasonable to speculate that some automatic mechanism may be operating. Research has revealed that some types of stimuli, like emotion-eliciting pictures, may activate an automatic allocation of more processing resources for storage. Whether pop-up ads are emotion-eliciting stimuli is still an open question. If the answer is no, then what mechanism causes the superior ad recall for pop-up ads than banner ads? As Lang (2000) noted,

> In the same way that the orienting response allocates resources to encoding, there appear to be other automatic processes that operate to automatically allocate resources to storage. A specific mechanism, akin to the orienting response, has not yet been proposed for this task. (p. 53-54)

Media researchers need to make concerted efforts to further investigate the possibility that some intrinsic property of pop-up ads could be aiding automatic allocation of resources for storage.

Another possibility to account for the higher recall for pop-up ads is that information related to banner ads might be written over after the onset of pop-up window. Given that pop-up ads appear on the screen 15 seconds later

than the banner ads, if the encoded banners have not been stored yet when pop-up ads appear on the screen, they may be written over by the newly encoded pop-up ads. Even though more cognitive resources are allocated for encoding because of the OR-eliciting effect of pop-up windows, the processing resources may not be exhausted (Lang, Borse, et al., 2002). Under this circumstance, pop-up ads will be further processed, that is, better stored and retrieved.

From a practical standpoint, the findings of the current study indicate that Web-site developers and marketing practitioners should not be discouraged by the potential of pop-up windows to cause annoyance (Kamp, 2001) but carefully take advantage of this formal feature in grabbing online viewers' attention and, hence, increasing brand awareness. This may or may not be a good thing, depending on the eventual behavior that it influences: Although awareness is generally considered by advertisers to be positively related to purchase intention, it might also motivate a negative behavioral response. At least one recent industry study has made the claim that online users actively penalize brands that use pop-ups and mistrust the companies that use and host pop-ups (Best, 2004). Another practical implication for advertising industry is to develop more innovative types of advertising. The lack of animation effect and the relatively inferior effect of banner ads on OR demonstrate the necessity for exploring more-creative executional cues to increase advertising effectiveness accruing from novelty effects.

Of course, we cannot generalize extensively given the external-validity limitations of a controlled lab experiment with forced exposure to the Web pages. In reality, the user's ability to control the Web-surfing experience is one of the features that distinguish the Web from traditional media. Further research should include this feature in investigating the interaction between online viewers and aspects of the mediated message. In addition, participants in the current study were undergraduate students, and the advertised products involved were high-involvement products for them. Therefore, the results may be specific to this group of participants and advertisements.

Unlike prior studies, the current investigation had banner ads and pop-up ads appear on the same Web page. The current study clearly points to the physiological and psychological importance of ad type as a variable for scholars as well as advertisers. In this unique setting, the effects of animation condition also become quite complex and contingent on content attributes (site ID), as well as other formal features, such as ad type. Future research would benefit by considering a variety of these characteristics in combination instead of studying structural features or content aspects in isolation, so that we can gain a fuller understanding of how mediated commercial messages on the Web are processed.

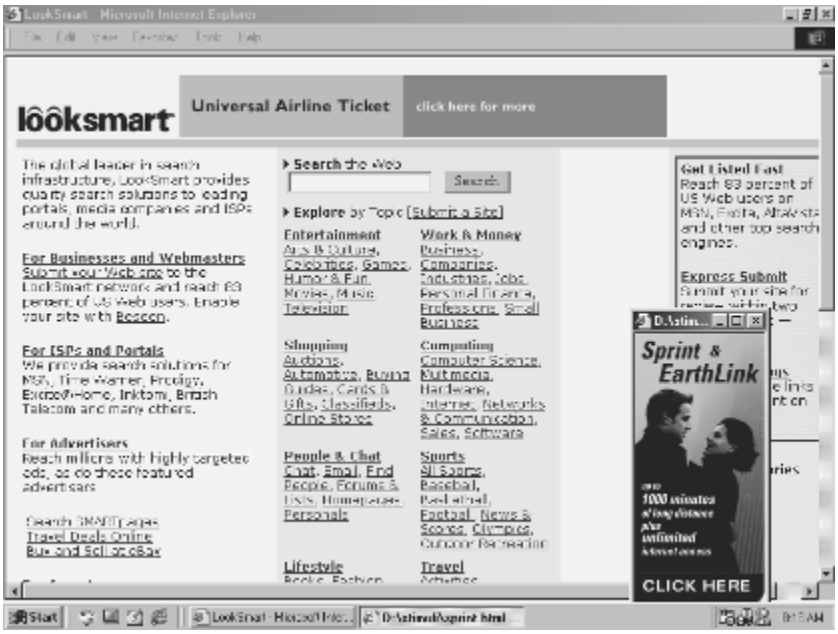
Appendix A
Experimental Stimuli

Site A

Site B


altavista
Canon S400 Color Bubble Jet Printer
Value @ $94.99
Click for Savings!
EGGHEAD
WHAT'S HOT: Eminem's Official Site | Wine Cellars | TaxCut from H&R Block
Web Page Search:
Search
Hip-Zip
MP3 Player
Music
People & Chat
Personal
Travel
AltaVista & Your Business

Site C


looksmart
Universal Airline Ticket
click here for more
Search the Web
Search
Explore by Topic (Submit a Site)
Entertainment
Work & Money
Shopping
Computing
People & Chat
Sports
Lifestyle
Travel
Get Listed Fast
Express Submit
Sprint & EarthLink
1000 minutes of long distance plus unlimited
CLICK HERE

Site D

Notes

1. Address all correspondence to S. Shyam Sundar, College of Communications, 212 Carnegie Building, Penn State University, University Park, PA 16802-5101; e-mail: sss12@psu.edu

2. The distinction between formal features and structural features is made to indicate the difference between the form in which an ad is delivered (e.g., pop-up vs. banner; html e-mail vs. plain-text e-mail) and the manner in which the ad is structured to behave (e.g., animated vs. static, interactive vs. noninteractive). Features of form may be producer controlled or receiver controlled whereas structural features are always producer controlled.

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