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The Impact of Salient Advertisements on Reading and Attention on Web Pages

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Human vision is sensitive to salient features such as motion. Therefore, animation and onset of advertisements on Websites may attract visual attention and disrupt reading. We conducted three eye tracking experiments with authentic Web pages to assess whether (a) ads are efficiently ignored, (b) ads attract overt visual attention and disrupt reading, or (c) ads are covertly attended with distraction showing up indirectly in the reading performance. The Web pages contained an ad above a central text and another ad to the right of the text. In Experiments 1, 2, and 3A the task was to read for comprehension. Experiment 1 examined whether the degree of animation affects attention toward the ads. The results showed that ads were overtly attended during reading and that the dwell times on ads were the longest when the ad above was static and the other ad was animated. In Experiments 2 and 3, the ads appeared abruptly after a random time interval. The results showed that attention (i.e., the time when the eyes first entered an ad) was related to the ad onset time. This happened especially for the ad to the right, indicating that ads appearing close to the text region capture overt attention. In Experiment 3B the participants browsed the Web pages according to their own interest. The study demonstrated that salient ads attract overt visual attention and disrupt reading, but during free browsing, ads were viewed more frequently and for longer time than during reading.

Keywords: reading, eye movements, online advertising, abrupt onset, task-orientation

Previous research on the processing of online advertisements has mainly focused on how frequently and for how long ads are viewed. A common finding in these studies has been that users rarely look at ads directly. Researchers have thus suggested that Web users learn strategies that help them ignore ads and maintain their focus on the primary task (e.g., Stenfors, Morén, & Balkenius, 2003). These findings have led some authors to question the applicability of visual attention theories to the Web environment, and to suggest that Web designers should not worry about the ads because they are too small to interfere with the users' primary task (Diaper & Waelend, 2000). A possible reason for why users have been observed to ignore online advertising might be that the studies have used small ad graphics, simplistic Web page layouts (e.g., word arrays or lists on a white background) and the tasks have been somewhat artificial (e.g., reaction time or visual cueing tasks) when compared to everyday online tasks (Burke, Hornof, Nilsen, & Gorman, 2005; Day, Shyi, & Wang, 2006; Stenfors et al., 2003; Zhang, 2000). The present study used standard-sized online ads and a Web page layout adopted from an authentic Web portal to investigate the allocation of attention toward advertisements during online reading. Another aim was to correct earlier misconceptions about the applicability of attention theories to the Web environment by demonstrating that the theories do generalize to the visual environment of the Internet. We also discuss practical implications of the present results for Web page design.

Previous eye tracking studies on advertising have mainly examined the visual processing of print advertisements (Radach, Lemmer, Vorstius, Heller, & Radach, 2003; Rayner, Miller, & Rotello, 2008; Rayner, Rotello, Stewart, Keir, & Duffy, 2001; Wedel, Pieters, & Liechty, 2008). It is important, however, to investigate the processing of online ads because, in contrast to print media, the Web environment allows the use of dynamic ad formats, such as animated and abruptly appearing ads. According to prior research such design cues capture visual attention efficiently, and thus processing of online ads is likely to differ from the processing of print advertisements. Moreover, the ubiquity of the online environment warrants research into the effects of online advertising on users' attention.

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Attention to Online Ads

The amount of information in our visual environment far exceeds what our visual system is able to process and assimilate into a conscious experience. The function of visual attention is to enhance the processing of selected stimuli. Models of visual attention often include the concept of a saliency map that integrates information across different features (e.g., intensity, orientation, color, etc.) into a single map encoding the visual saliency of objects (Itti & Koch, 2000). The maximum of the saliency map corresponds to the most salient location, which is thought to attract visual attention. On the other hand, inhibiting the most salient location and directing attention away from it requires voluntary effort.

Salient changes in the visual field may capture attention involuntarily in a stimulus-driven, *bottom-up* manner. Previous research has shown that during parallel search for a singleton target, participants cannot override the stimulus driven activation by salient stimulus attributes even when they are told to do so (Theeuwes, 1994). Voluntary attention, also termed as *top-down* or goal-directed attention, refers to attentional allocation based on individuals' current goals. Top-down attention allows users to actively maintain attention on the primary task or to shift attention voluntarily from one display region to another. Previous studies have demonstrated that the ability to selectively ignore distractors depends on the presence of an attentional set for target and distractor properties, suggesting that top-down control of attention is not possible without knowledge of the target and distractor features (Theeuwes & Burger, 1998). Moreover, Theuuwes and Burger observed that when the salient element was unpredictable and changed from trial to trial, it was not ignored and therefore interfered with visual search.

Previous studies suggest that Web users mainly rely on top-down strategies that help them ignore ads present in their visual field (Drèze & Hussherr, 2003; Stenfors et al., 2003). These studies propose that in the Web environment top-down control of attention is capable of overriding the bottom-up attentional capture by salient low-level visual features (e.g., color, orientation, luminance, or motion). For example, Burke et al. (2005) reported that ads containing only uniform gray color were looked at equally often as colored commercial ads including graphics, and that there were no differences between animated and static commercial ads.

In addition to bottom-up and top-down routes, the effects of visual attention can be divided into overt and covert influences. Covert attention allows us to attend to a specific location without moving our eyes to that location. That is, covert processing of advertisements occurs when an individual is exposed to ads in the peripheral visual field while overt visual attention is allocated around the foveal region. Previous research on covert processing of online ads has provided ambiguous findings. Some studies have demonstrated that ads interfere with the primary task. For example, Burke et al. (2005) reported longer search times in the presence of commercial banners compared to uniform gray banners, when the task was to search for exact matches of given headlines. Likewise, Hong, Tong, and Tam (2004) reported increased response times in an online shopping task when a nontarget shopping item was flashed. In contrast, Burke et al. (2005) demonstrated that when the task was to locate single words from lists of words, peripheral ads including both static and animated graphics decreased visual search times compared to when uniform gray banners were presented. Day et al. (2006) also found that online decision-making became faster when peripheral flash banners were presented compared to when no flash banners were presented. The authors concluded that peripheral ads might also increase the participants' level of arousal, which in turn motivates them to allocate additional processing resources. All these studies, along with that of Dréze and Hussherr (2003), report that participants rarely look at the ads overtly, suggesting that covert attention to the ads is responsible for the effects observed in the search and decision times.

Experienced Distraction

Although some studies have reported that Web users are able to avoid ads by top-down attentional control, other studies have demonstrated that the presence of ads results in increased workload, leading the users to experience the ads as intrusive and distracting. For example, Burke et al. (2005) asked participants to rate their impression of workload for different types of ads: uniform gray, static, animated, or flashing text ad. The flashing text elicited greatest subjective ratings of workload and was evaluated as the most frustrating and demanding. Animated commercial ads were rated slightly higher on workload than static ads. In the study by Diaper and Waelend (2000), participants' ratings suggested more attention being paid to animated than static graphics. Moreover, Yoo and Kim (2005) reported that subjective ratings of attentional demand were the highest when the speed of animation was fast compared to static ads or ads containing a moderate speed of animation. In the experiment by Zhang (2000), 88% of the participants reported that they would rather have no animated graphics in the same page where they performed a string search task. Animated color and string graphics were rated as the most distracting types of animation. Gao, Koufaris, and Ducoffe (2004) showed that the presence of continuous animation and pop-up ads resulted in higher perceived irritation that was associated with negative attitudes toward the Website. In addition, Hong et al. (2004) demonstrated that users had unfavorable attitudes toward a Web page when a nontarget item was flashed. Thus, previous research suggests a discrepancy between the Web users' performance and their subjective experience, that is, the users seem to be aware of the ads and they perceive them as distracting, yet they rarely look at the ads directly.

Overview of the Experiments

The present experiments investigated how online ads attract visual attention and affect reading of Web pages. By instructing participants to read the texts to answer multiple choice text content questions, attention was primarily directed toward the text, while the ads were considered secondary stimuli to the reading task. Based on earlier research, we expected that the ads might affect reading in three possible ways: (a) ads are ignored and thus do not affect reading, (b) ads attract visual attention and are overtly fixated, causing disruption to the ongoing reading process, or (c) covert attention to ads disrupts reading with the influence showing up only indirectly in the reading performance. These three hypotheses were tested in the three experiments.

As regards the first hypothesis, various studies have demonstrated that specific task demands may guide attention only to those parts of the display that are relevant for the task at hand (Theeuwes & Burger, 1998). Studies on online ad processing (Diaper & Waelend, 2000; Stenfors et al., 2003) further suggest that ads can be avoided by top-down attentional control. Thus, the first hypothesis is that ads are not attentively processed during online reading, but instead attention is directed to the text, which is relevant for the given task.

The second hypothesis proposes that standard-sized ads (especially the animated ones) are salient enough to direct attention in a bottom-up manner, and thus result in overt fixations to ads and interruptions to reading. Previous studies, which suggest that ads do not capture attention, have used rather simple Web page layouts, small ad sizes (in the range of 100 × 100 pixels), and the graphic contents may not have been comparable to authentic online ads (Diaper & Waelend, 2000; Zhang, 2000). Moreover, studies on visual attention indicate that abrupt changes (e.g., stimulus onsets, offsets, and motion) are capable of capturing attention involuntarily (Franconeri & Simons, 2003; Jonides & Yantis, 1988). Further support for the second hypothesis comes from subjective reports on experienced distraction, suggesting that users are aware of the ads, and they experience them as distractors to the main task (Gao et al., 2004; Hong et al., 2004).

The third hypothesis is that users have learned to ignore ads, but covert attention to ads results in an indirect processing cost, that is, a drop in reading performance. As suggested by Itti and Koch (2000), directing attention away from the most salient stimulus requires extra effort. This strategy suggests that users are aware of the processing cost associated with directing overt attention elsewhere, and therefore attempt to avoid attentional capture by peripheral distractors. This also implies that the user knows the perceptual properties of the objects being ignored (see Theeuwes & Burger, 1998). According to the central capacity theory of attention (Kahneman, 1973), if users spend some of their attentional resources on an interfering task, that is, covertly attending to ads, they will be left with fewer resources for the primary task, reading in our case. Moreover, because both the ads and text are presented in the visual modality, they compete for the same specific attentional resources (see Allport, 1980).

To test the three aforementioned hypotheses about allocation of attention to online ads during reading, we recorded participants' eye movements and analyzed the results relative to the text and ad areas. Eye movements provide an excellent indicator of the locus of overt visual attention, because attention and targeting of saccades are tightly linked together (Deubel & Schneider, 1996; Doré-Mazars, Pouget, & Beauvillain, 2004). Well-established eye movement metrics such as fixation durations and number of fixations (Rayner, 1998) were used as indices of the online reading process. Reading rates and responses to the text content questions were collected to assess reading performance. As argued above, avoidance of ads is observed if the participants do not fixate the ads and the reading performance stays constant under different online ad conditions. On the other hand, direct processing cost is observed if the ads attract overt attention (i.e., participants fixate them directly), resulting in interruptions in and slowing down of the ongoing reading process. Finally, an indirect processing cost is observed if the reading performance drops while the ads are not overtly fixated.

The selected Web page layout comprised a central text and two online ads located either above or to the right of the text. The ad above the text was aligned horizontally and the ad to the right was vertically aligned. The ad locations and formats corresponded to a standard Web page layout. In the present study, ad location rather than ad format was more important for making predictions about allocation of attention to different parts of a Web page. Previous studies (McConkie & Rayner, 1975; Rayner, 1998) indicate that for readers of Western languages, the perceptual span is biased toward the right of fixation, that is, they acquire more information (about 15 letters) to the right of fixation than to the left (only about 3–4 letters). Therefore, we expected that because of its proximal location, the ad to the right of the text would attract more attention than the ad above the text. Prior research has shown location effects on attention toward online ads. For example, ads positioned in the lower visual field attract more attention than ads in the upper visual field (Goodrich, 2010). Other studies have emphasized the effect of format on ad perception and memory (Kuisma, Simola, Uusitalo, & Öörni, 2010) as well as on attitudes toward online advertising (Burns & Lutz, 2006).

The salient visual feature of the ads in Experiment 1 was motion (animation), whereas Experiment 2 tested the effect of abrupt ad onsets on reading. Finally, to determine the degree to which a given task affects ad perception, Experiment 3 assessed the effect of task-orientation on the processing of online ads by instructing the participants to browse the pages according to their own interests.

Experiment 1

Advertisers incorporate fast moving images in online ads to capture attention and to break through the information clutter on Websites. Previous studies suggest that the human visual system allows priority to behaviorally urgent events such as dynamic discontinuities (e.g., abrupt onsets and movement) in the environment (Franconeri & Simons, 2003; Theeuwes, 1994). In addition, research has shown that attention can be directed efficiently to moving items and that their presence is detected even if attention is allocated elsewhere (McLeod, Driver, & Crisp, 1988; McLeod, Driver, Dienes, & Crisp, 1991). Experiment 1 tested whether the degree of peripheral motion inherent in animated ads affects attentional allocation and online reading. The stimulus displays included one ad above the text and another ad to the right of the text (see Figure 1). Our expectation was that a high degree of animation (both ads simultaneously animated) attracts attention and distracts reading more than when only one of the ads is animated. The smallest effects were expected when both ads are static.

Method

Participants. Twenty-eight volunteers with normal or corrected to normal vision participated in the experiment. Table 1 shows demographic information about the participants and their previous experience with the Internet. All participants provided written informed consent and they were paid to participate in the experiment.

Apparatus. Eye movements were recorded by a Tobii 1750 remote eye-tracking system with a spatial accuracy of .5°. The

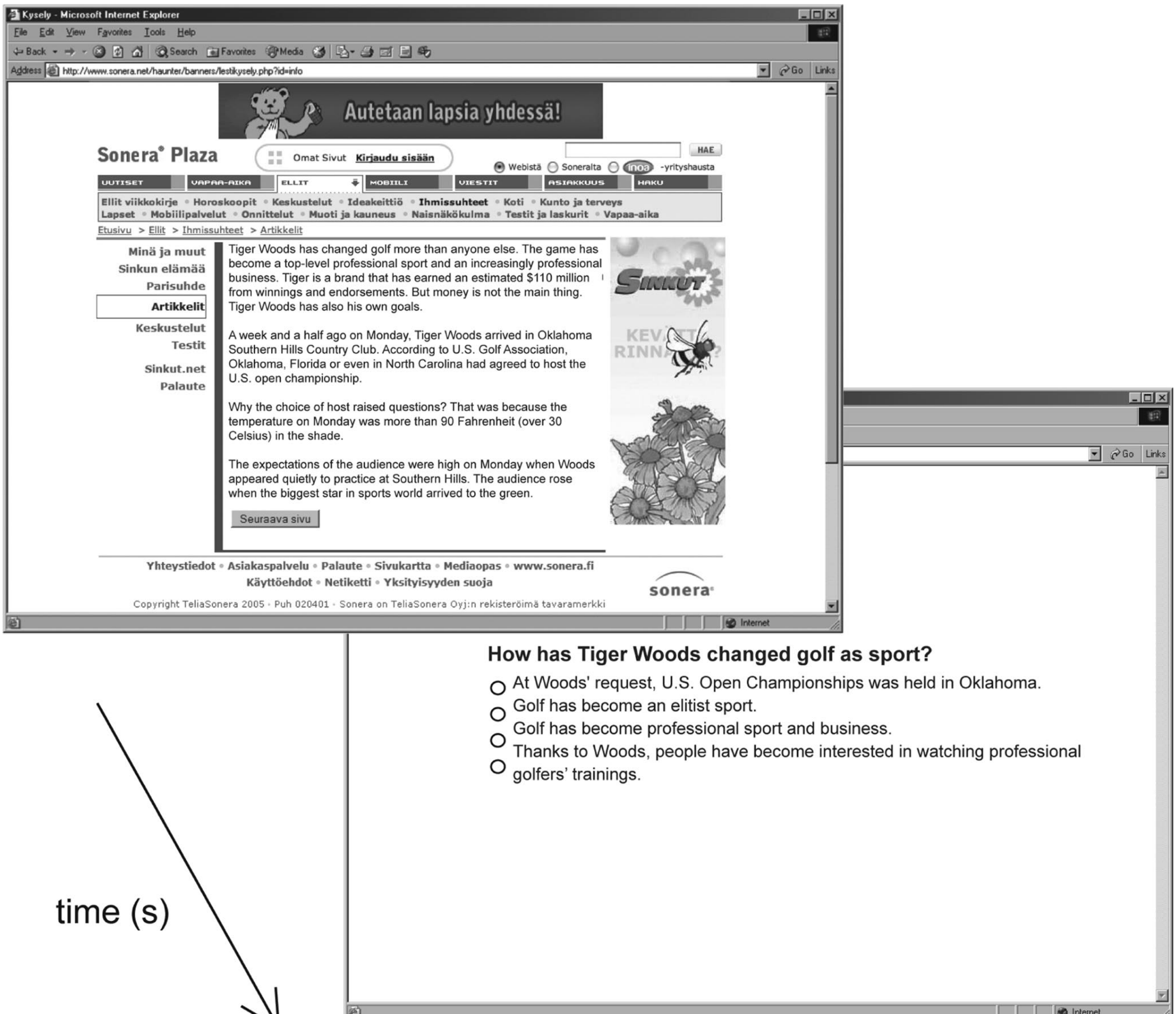

Figure 1. A black-and-white version of the Web pages used in the study (the actual Web pages were colored) with an example text and a four-choice question translated into English from the original Finnish version. For illustration purposes, a larger font size for the questions is used here than in the actual experiments.

screen coordinates of both eyes were sampled at 50 Hz. For each participant, the system was calibrated before the experiment using a set of 16 calibration points shown one at a time and covering the whole screen area. The stimuli were presented on a 17-inch display with a screen resolution of 1024 × 768 pixels. The display was located on a table at the distance of ~60 cm from the participants' eyes.

Materials. The stimuli comprised 32 Web pages each containing a text, an ad above the text, and another ad to the right of the text (see Figure 1). The text material contained 32 online magazine articles of 90–118 words, with mean length of 104 words, and with an average word length of 6.8 characters. The texts were modified from the text materials previously used in Laarni, Simola, Kojo, and Näsänen (2004) and were written in Finnish in a 14-point Arial font. From the viewing distance of 60 cm, the average character height was .4° and the average width was .3°. The texts were about music, religion, advertising, art, business, and golf.

The advertisements consisted of 64 full-color ads depicting 16 different topics (7 cellular phone and 3 broadband subscriptions, 2 mobile games, a lottery, a magazine, a holiday, and a charity campaign). Previous studies investigating the effect of animation have been criticized for lacking an adequate control between the static and the animated conditions, and for not providing comparable content and amount of information, or for confounding the effect of animation with other factors, such as interactivity (reviewed in Tversky, Morrison, & Betrancourt, 2002). To control for the effects of ad content, four different versions of each ad topic

Table 1
Background Information About the Participants

	Exp. 1	Exp. 2	Exp. 3A	Exp. 3B
N	28	30	32	30
N of females	14	15	16	15
Mean age (*SD*)	35.1 (7.3)	34.1 (10.1)	37.6 (9.8)	29.4 (10.0)
Age range	19–49	20–58	18–53	19–54
Education				
High school/vocational school	10	12	26	7
University/college	17	18	6	23
Computer and Internet experience in years (*SD*)				
Computer experience	16.4 (4.4)	16.3 (4.2)	14.8 (6.8)	14.0 (4.0)
Internet experience	9.71 (3.0)	11.4 (2.3)	9.61 (2.6)	10.5 (2.5)
Internet use				
Daily	24	30	28	30
Weekly	4	—	3	—

were professionally designed so that the same topic was presented above the text in static and animated versions, and also to the right of the text in static and in animated versions. Thus, each participant saw the same advertisements in four different versions during the experiment, but different versions of the same topic never appeared simultaneously on a Web page. The static ads consisted of representative frames from the corresponding animated ads, and the animations included horizontal, vertical and/or rotating movement, appearing and fading graphics, or text objects.

The Web page layout was adopted from the former front page of a commercial portal, and it included two ads meeting the international standards. The ad above the text subtended 14.4 × 2.0° (468 × 60 pixels), and the ad to the right of the text subtended 4.4 × 11.6° (140 × 350 pixels). Both ads were simultaneously visible, and were presented under the following four conditions: both ads were static (S + S), the ad above was static and the ad to the right was animated (S + A), the ad above was animated and the ad to the right was static (A + S), and both ads were animated (A + A). A Latin square design was used so that each participant read an equal number of texts in each condition (eight texts per condition), while across participants each text was read in each condition by an equal number of participants. In addition, the assignment of different texts and ad combinations to different conditions was randomized to prevent possible interactions between the text and ad contents; however, the text and ad contents were not related. The conditions were presented in a randomized order, and the presentation was controlled by a Java-software developed for the experiment. The Web pages were displayed using Internet Explorer Web browser. The text and ads fitted in one screen so no scrolling was necessary.

Procedure. Participants were told that the experiment concerned online reading, and nothing was said about the advertisements. They were instructed to read 32 texts to be able to answer a multiple-choice content question presented after each text (see Figure 1). Participants read the texts at their own pace while their eye movements were recorded. After they finished reading a text, they clicked on a link below, and a four-choice question appeared. Answering the question prompted the next stimulus to appear. After participants had finished reading all the texts, they were asked to rate, on a scale from 1 to 5, whether they had paid attention to the ads and whether the ads had interfered with reading. The experiment lasted about 30 min.

Data analyses. Fixations, saccades and blinks were extracted from the raw eye coordinate data with Tobii Clearview software using a window-based algorithm with 40 pixel window and a minimum fixation duration of 100 ms. To measure reading performance as a function of the overall scanning on the Web page, reading rates were calculated as the number of words covered in the total time spent on the page (words per minute, wpm). Comprehension accuracy was measured as the proportion of correct answers in the multiple-choice questions. To test whether the ads interfered with reading either overtly (fixations to the ads), or covertly (no fixations detected on the ads, but a drop in reading performance), we calculated eye movement measures separately for the ad and the text regions (see Figure 1). For the ad regions two frequency measures (number of entries and total number of eye fixations) and two time measures (time of first entry and total dwell time = summed duration of all fixations) were calculated. For the text region, in addition to the frequency measures and the time of text entry, we calculated the mean fixation duration and the number of saccades directed backward in the current text line (regressions), because these measures provide a good indicator of reading difficulty. Previous research has shown that text difficulty strongly influences the number of regressions, and that regressions most likely indicate comprehension failures, because when readers determine that their interpretation of a sentence is wrong or they have failed to adequately comprehend it, they often regress back to the relevant text region to reprocess parts of the text (as reviewed in Rayner, 1998). Moreover, longer fixation durations and more frequent fixations during reading are associated with processing difficulty, for example, longer eye fixations have been observed for misspelled, less common or unpredictable words (Rayner, 1998).

Differences in reading performance and eye movement measures concerning the text area were studied with a repeated measures analysis of variance (ANOVA). The effect of Ad Type (animated vs. static) was studied for both ad Locations (above vs. right), because in the experimental design both ads were always presented simultaneously. Furthermore, we studied the interactions between Ad Type and Location. Around 40% of the participants reported that they had paid attention to ads constantly or relatively often, and 68% reported that animated ads interfered with reading constantly or at least occasionally. We tested the relation of participants' self-reports to eye movement measures by adding participants' self-reported attention and distraction as binary between-participants factors to the ANOVA model. Furthermore, the relation between comprehension accuracy and eye movements was tested by adding the mean comprehension scores to the model.

The eye movement measures for the ads were subjected to a Generalized Estimating Equations (GEE) model. The GEE-model also tested the effects of participants' self-reported attention to ads and distraction by ads as well as comprehension accuracy on eye movement measures concerning the ads. A negative binomial distribution using log link was used for frequency measures and a gamma regression using the inverse link was used for time measures. A negative binomial distribution is typically used for analyzing count measures, and a gamma distribution is often used to model eye movement data (e.g., Wedel et al., 2008). The structure of the within-participant covariance matrix was set to independent, and least significant difference (LSD) tests were used for the post hoc comparisons.

GEE (e.g., Hardin & Hilbe, 2003) is an extension to the standard array of Generalized Linear Models (GLMs). As likelihood-based models, traditional GLMs are based on the assumption that individual subjects or observations are independent. GEE models do not require such an assumption, and can thus handle situations where responses are correlated. GEE models can also handle data with missing values (e.g., in our data roughly 70–80% of the trials did not contain eye movements to ads) more efficiently than the traditional repeated measures ANOVA, which is based on the assumption that all missing values can be omitted (Diggle, Heagerty, Liang, & Zeger, 2002). The design of the present study is a traditional repeated measures design where the distributions of outcome variables are non-normal (e.g., variables such as the number of fixations and fixation duration on ads are strongly skewed to the right) and the structure of the missing value pattern can be considered missing at random (Little & Rubin, 1987). Therefore, the GEE model is well suited for this kind of design and was used in the present study.

Results

Reading performance, eye movements, and subjective reports. Animation of the ad to the right of the text did not affect reading, whereas animation of the ad above the text resulted in numerical differences in the mean number of regressions during reading and the text entry times. That is, the mean number of regressions was higher (19.37 ± 8.68 *SD*) when the ad above was animated than when it was static (18.77 ± 8.78 *SD*), although this difference did not quite reach significance ($F(1, 23) = 3.60$, $p = .070$, $\eta_p^2 = .135$). Similarly, the text was entered somewhat later when the ad above was animated (.65 ± .69 *SD*) compared to when it was static (.60 ± .62 *SD*), but this effect did not reach significance either ($F(1, 23) = 3.71$, $p = .067$, $\eta_p^2 = .139$). Table 2 shows the means of reading performance and eye movement measures on the text region.

Participants who reported that they had paid attention to ads entered the text later (.99 ± 1.67 *SD*) than those who reported no attention to ads (.39 ± .42 *SD*) ($F(1, 23) = 4.98$, $p = .036$, $\eta_p^2 = .18$). Reported distraction interacted with animation of the ad above the text in number of fixations ($F(1, 23) = 6.28$, $p = .020$, $\eta_p^2 = .214$) made during reading, suggesting that those who did not report distraction made fewer fixations ($p = .012$) when the ad above the text was static. Furthermore, reported ad distraction ($F(1, 23) = 6.16$, $p = .021$, $\eta_p^2 = .211$) and comprehension accuracy ($F(1, 23) = 4.15$, $p = .053$, $\eta_p^2 = .153$) affected reading rates, indicating that reading was slow when the reported distraction and comprehension accuracy were high.

Table 2
Means of Reading Performance and Eye Movement Measures on the Text in Experiment 1, as a Function of Ad Condition

Ad condition	S + S	S + A	A + S	A + A
Reading performance				
Comprehension	.88	.89	.85	.87
Reading rate (wpm)	216.91	220.13	197.41	194.40
Eye movements on the text				
No. of entries	1.93	2.09	2.27	1.92
No. of fixations	93.81	98.17	100.60	95.56
No. of regressions	18.20	19.33	20.17	18.65
Time of entry (s)	.58	.62	.70	.61
MeanFixDur (ms)	208.19	214.38	211.84	210.33

Note. Time of entry is calculated in seconds from the trial onset. S + S = both ads were static; S + A = the ad above was static and the ad to the right was animated; A + S = the ad above was animated and the ad to the right was static; A + A = both ads were animated.

Eye movements on the ad above the text. On average, participants fixated the ad above the text in 21% of the trials. Figure 2 illustrates the mean number of entries and fixations to ads per trial. GEE model showed that the number of entries to the ad above the text was higher when the ad to the right was static (.45 ± 1.11 *SD*) compared to when it was animated (.25 ± .86 *SD*) ($\chi^2(1) = 6.58$, $p = .010$) (see Table 3). Furthermore, the analysis showed an Ad Type × Location interaction for the dwell time on the ad above the text ($\chi^2(1) = 11.53$, $p = .001$), suggesting longer dwell times when the ad above was static and the ad to the right of the text was animated (S + A) compared to all other conditions, that is, when both ads were static (S + S) ($p = .013$), or animated (A + A) ($p = .012$), or when the ad above was animated and the ad to the right of the text was static (A + S) ($p = .011$) (see Table 3).

The total dwell time on the ad above the text was longer for participants who reported attention to ads (.51 ± 1.33 *SD*) compared to those who did not report attention to ads (.42 ± 3.46 *SD*) ($\chi^2(1) = 5.29$, $p = .021$). Participants' self-reported distraction was associated with the entry time on the ad above the text ($\chi^2(1) = 4.27$, $p = .039$), suggesting later ad entries for those who reported distraction (16.81 ± 20.00 *SD*) compared to those who did not report distraction (10.38 ± 15.74 *SD*).

Eye movements on the ad to the right of the text. Participants fixated the ad to the right of the text in about 27% of the trials. The ad to the right was entered and fixated more often than the ad above the text (see Figure 2). The number of entries ($\chi^2(1) = 3.90$, $p = .048$) and the number of fixations ($\chi^2(1) = 9.92$, $p = .002$) for the ad to the right of the text were higher when it was animated compared to when it was static, but both effects were qualified by an Ad Type × Location interaction (see Table 3). These interactions suggest that the number of fixations on the ad to the right was the highest in the S + A condition, compared with all other conditions, that is, the S + S condition ($p = .005$), the A + A condition ($p = .035$), and the A + S condition ($p = .011$).[1] An Ad Type × Location interaction was also observed for the dwell time on the ad to the right of the text ($\chi^2(1) = 6.55$, $p = .010$), indicating the longest dwell times in the S + A condition compared with all other conditions, that is, the S + S condition ($p = .025$), the A + A condition ($p = .034$), and the A + S condition ($p = .017$). Participants who reported attention to ads ($\chi^2(1) = 8.50$, $p = .004$) and distraction by ads ($\chi^2(1) = 9.81$, $p = .002$) fixated the ad to the right of the text more often (2.03 ± 3.72 *SD* and 1.50 ± 3.26 *SD*) than participants who did not report attention or distraction (.50 ± 1.75 *SD* and .26 ± .92 *SD*).[2]

Discussion

The results of Experiment 1 showed a clear pattern of increased attention to both ads in the condition where the ad above the text was static and the ad to the right of the text was animated (the S + A condition). Our expectation was that the highest degree of animation (both ads animated simultaneously) would attract the most attention. However, contrary to our expectations, the results suggest that a top-down control of attention to ignore the ads failed most often when there was moderate amount of animation. This finding was supported by increased dwell times on both ads as well as by the greater number of entries and fixations toward the ad to the right of the text in the S + A condition. The results support the hypothesis that the ads distract reading and that distraction by ads occurs through overt fixations toward ads rather than as covert processing of ads during reading.

The results also show that the ad to the right was attended more often than the ad above the text. Moreover, when the amount of animation was moderate (the S + A condition), animation increased attention toward the ad to the right, whereas no such effect was found for the ad above (the A + S condition). In contrast, the ad above the text was attended more often when the ad to the right was static, suggesting that when the ad to the right was animated, less attention was directed to other parts of the Webpage. Thus, the results indicate that animation presented in the proximity of the text attracts more attention compared to when the animated ad is presented in the periphery. This interpretation is based on the fact that when reading the text from left to right, the eyes come very close to the ad on the right each time the reader reaches the end of a text line (see Figure 1). Therefore, it is likely that the ad on the right, at least occasionally, enters the region of effective vision (i.e., the perceptual span, see Rayner, 1998), resulting in occasional fixations on the ad.

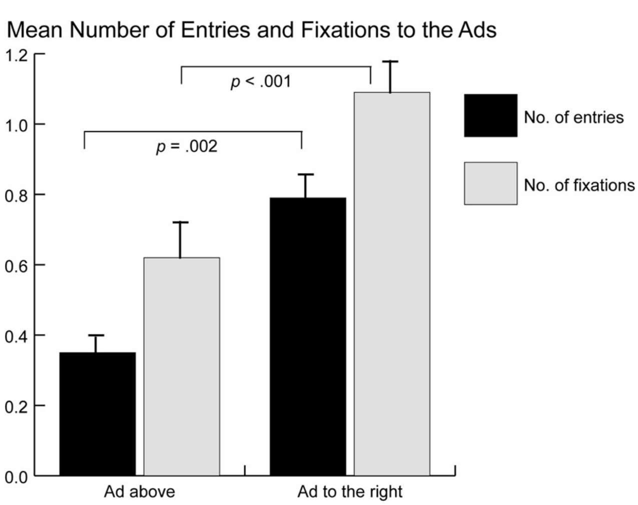

Figure 2. Number of entries and number of fixations to the ads in Experiment 1. Brackets indicate significant differences in Wilcoxon signed-ranks test. Error bars indicate *SE*.

Table 3
Eye Movement Measures for the Ad Above and the Ad to the Right of the Text in Experiment 1, as a Function of Ad Condition

Ad condition	S + S	S + A	A + S	A + A
Ad above text				
No. of entries	.40	.28	.50	.23
No. of fixations	.86	.80	.96	.51
Time of entry (s)	15.35	16.98	15.72	13.10
Dwell time (ms)	924.39	1560.72	878.63	753.55
Ad to the right of text				
No. of entries	.48	.77	.64	.59
No. of fixations	.74	1.55	1.02	1.03
Time of entry (s)	13.69	15.39	13.26	15.90
Dwell time (ms)	796.04	1462.82	895.71	872.80

Note. Time of entry is calculated as seconds from the trial onset. S + S = both ads were static; S + A = the ad above was static and the ad to the right was animated; A + S = the ad above was animated and the ad to the right was static; A + A = both ads were animated.

To further examine whether attention to ads occurred in a covert or overt fashion, we included participants' self-reported attention and experienced distraction by ads to the analyses. The results showed later text entries for participants who reported attention to ads, and slower reading rates for those who reported distraction. Furthermore, participants who reported being distracted by the ads had longer dwell time and fewer fixations on the text when the ad above was static. From the ad processing perspective the results show that participants who reported paying attention to ads looked at the ad above longer and entered the ad to the right more often than participants who did not report attention to ads. Moreover, participants who were distracted by the ads entered the ad above the text later than participants who did not report distraction. However, attention toward the ad on the right increased for those participants who reported that they attended to the ads and were distracted by them. This pattern of results possibly suggests that the ad above the text was attended covertly whereas the ad on the right was attended overtly.

The findings of Experiment 1 suggest that especially the animated ads to the right of the text were overtly attended (i.e., fixated) during reading, even when they were irrelevant to the task at hand. Participants' self-reports further supported the finding that ads attracted overt attention and also distracted reading. Thus, in

[1] A similar pattern was observed for the number of entries toward the ad to the right, suggesting a higher number of entries in the S + A condition compared to when both ads were static (S + S) ($p = .014$) or animated (A + A) ($p = .045$).

[2] The number of entries revealed a similar, statistically significant pattern.

contrast to previous studies (Drèze & Hussherr, 2003; Stenfors et al., 2003), our results show that ads are not always efficiently avoided, but they may interrupt the reading process by capturing participants' overt attention to ads. Thus, contrary to the hypothesis that online ads can be efficiently ignored, the results of Experiment 1 suggest that ads do attract attention and are overtly fixated. The results also go against those of Diaper and Waelend (2000) who concluded that Web page designers should not be concerned about the effects of graphics on Web pages, because typical ads are too small to interfere with the main task. On the contrary, our results suggest that animation should be applied with care, because it can capture attention and interfere with the online reading process.

It is noteworthy, however, that participants fixated the ads rather late, that is, after around 15 s from the trial onset, and that the ads were fixated in less than one third of the trials. Previous studies have shown that even though visually salient features can be efficiently detected, it does not necessarily indicate that all salient features capture attention. For example, objects exhibiting motion do not necessarily draw attention when motion is uninformative about the target location (Hillstrom & Yantis, 1994; Yantis & Egeth, 1999). To increase the salience of ads, we delayed their appearance in Experiment 2, as prior research suggests that task-irrelevant abrupt stimulus onsets efficiently capture visual attention (e.g., Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999; Yantis & Jonides, 1984).

Experiment 2

Experiment 2 tested the effect of delayed ad onset time on attention toward ads and online reading performance. Previous research has shown that people are able to ignore some task-irrelevant salient features, such as motion, color or brightness, but that an abrupt appearance of a new object efficiently captures attention in a bottom-up fashion (e.g., Hillstrom & Yantis, 1994). These studies have demonstrated faster response times to abrupt-onset targets than to targets that are present from the beginning of the search trials (Jonides & Yantis, 1988; Yantis & Hillstrom, 1994; Yantis & Jonides, 1984), and that the response times to abrupt-onset targets do not increase with the number of elements in the array, whereas substantial array size effects are observed for no-onset targets. Attentional capture by stimulus onset could not be attributed to deviant or unique stimulus features such as luminance increment (Yantis & Hillstrom, 1994), color (Jonides & Yantis, 1988), or motion (Hillstrom & Yantis, 1994), indicating that abrupt visual onsets per se are sufficient to capture attention. On the basis of these studies, it is concluded that processing of abrupt onsets differs fundamentally from the way other distinctive features are processed, in that stimulus onset captures attention and is examined first, whereas processing of salient items defined by brightness or color does not differ from processing of other items in the array.

Furthermore, Brockmole and Henderson (2005) showed that abruptly appearing new objects capture attention also in real-world scenes, especially when the new object appears during a fixation and introduces motion in the visual field. Gaze was also found to be directed to a new object appearing during a saccade, when input of visual information is switched off, suggesting that transient onset is not necessarily required for the new object in a scene to influence gaze. Thus, new objects could also be prioritized through top-down attentional control, but without transient onsets observers need to rely on their memory representation of the scene to guide attention and to localize the changes.

To our knowledge, no earlier studies have examined the effects of abrupt ad onsets on online reading and attention. The ad appearance was delayed so that either the ad above the text or the ad to the right of the text appeared on the screen after a random delay of 0–12 s. The abrupt onset conditions were compared to conditions, where either the ad above or the ad to the right of the text was present throughout the trial. This approach made it also possible to separate out the independent effect of ad location on reading, which was not the case in Experiment 1 where both ads were simultaneously visible throughout the trial.

Method

Participants. Thirty volunteers gave an informed consent and were paid to participate in Experiment 2 (see Table 1). All had normal or corrected-to-normal vision. They were not aware of the purpose of the study, and none of them took part in Experiment 1.

Procedure. The same texts, advertisements and Web page layout were used as in Experiment 1, and the task was again to read the texts for comprehension. The experimental procedure was similar to Experiment 1, except for the ad conditions. To test the effect of abrupt ad onsets on attention toward the ads, the following conditions were used: (a) the ad above the text was present throughout the trial, (b) the ad above the text appeared after a random delay of 0–12 s, (c) the ad to the right of the text was present throughout the trial, (d) the ad to the right appeared after a random delay of 0–12 s.

Data analyses. To ensure compatibility of results with those of Experiment 1, similar procedures for data preprocessing and statistical analyses were used. Reading performance and eye movement measures concerning the text area were subjected to a 2×2 repeated measures ANOVA with Ad Location (above vs. right) and Abrupt Onset (no-onset vs. onset) as within-participant factors. Eye movements landing on both ad regions were analyzed using the GEE model. Paired comparisons were performed for fixations on the ad above the text between conditions where the ad was present throughout the trial or when it appeared abruptly (Conditions a and b). Similarly, fixations landing on the ad to the right were compared between the two onset conditions (Conditions c and d).

Around 53% of the participants reported that they had paid attention to ads constantly or relatively often, and around 53% of them reported that ads interfered with reading constantly or at least occasionally. They formed the groups who reported attention to ads and distraction by the ads. The relation of self-reports to eye movements was tested by adding participants' self reported attention and distraction as between-participants factors to the statistical models. Furthermore, the relationship between comprehension accuracy and eye movements was tested by including participants' answers to text content questions in both models.

To examine the effect of abrupt ad onset on attention toward the ads, the ad onset time was included in the GEE model, and correlations were calculated between the abrupt ad onset time and the time of first fixation landing on the ad. Spearman's r was used because the distributions were skewed and nonlinear. Moreover, we calculated the number of fixations intervening between the ad onset and the observers' first fixation on the ad as a measure of how quickly the onset captured attention. We first report how the ad conditions affected reading and attention toward the ads (i.e., fixations on the text and ad regions) and then how abrupt onsets captured attention.

Results

Reading performance, eye movements, and subjective reports. Ad location affected comprehension accuracy ($F(1, 27) = 4.22$, $p = .050$, $\eta_p^2 = .135$), reflecting poorer comprehension when the ad was presented to the right than above the text (see Table 4). The main effect was qualified by an Ad Location × Abrupt Onset interaction ($F(1, 27) = 4.40$, $p = .045$, $\eta_p^2 = .140$), suggesting that comprehension was somewhat poorer in the onset-right than in the onset-above condition ($p = .026$). However, comprehension was better when the ad above the text appeared abruptly compared to when it was present throughout the trial ($p = .033$). Ad location affected also reading rate ($F(1, 26) = 6.48$, $p = .017$, $\eta_p^2 = .199$), suggesting that reading was slower when the ad above the text was presented compared to when the ad to the right was presented. Slower reading rates were further associated with improved comprehension accuracy ($F(1, 26) = 5.68$, $p = .025$, $\eta_p^2 = .179$), but this effect interacted with ad location ($F(1, 26) = 5.93$, $p = .022$, $\eta_p^2 = .186$), suggesting that the effect was stronger in the conditions where the ad to the right was presented. Improved comprehension was also associated with greater number of fixations ($F(1, 26) = 9.02$, $p = .006$, $\eta_p^2 = .258$) and regressions ($F(1, 26) = 6.29$, $p = .019$, $\eta_p^2 = .195$) on the text region.

Participants who reported paying attention to ads entered the text more often (2.90 ± 2.50 *SD*) ($F(1, 26) = 5.52$, $p = .027$, $\eta_p^2 = .175$) and they had longer mean fixation duration (286.86 ± 49.07 *SD*) during reading ($F(1, 26) = 11.73$, $p = .002$, $\eta_p^2 = .311$) compared to participants who reported no attention to ads (1.38 ± .36 *SD* and 235.41 ± 36.50 *SD*).

Eye movements on the ad above the text. On average, participants fixated the ad above the text on 14% of the trials. Figure 3 shows the mean number of entries and fixations to the ads. According to the GEE model, abrupt onset affected the number of entries ($\chi^2(1) = 12.09$, $p = .001$) and number of fixations ($\chi^2(1) = 10.23$, $p = .001$), suggesting higher number of entries and fixations on the ad above the text when it appeared abruptly compared to when it was present throughout the trial (see Table 5).

Participants who reported attention to ads entered ($\chi^2(1) = 11.26$, $p = .001$) and fixated ($\chi^2(1) = 21.97$, $p < .001$) the ad above the text more often than participants who did not report attention to ads (see Table 6). They also entered the ad above sooner ($\chi^2(1) = 13.42$, $p < .001$) and had longer dwell times on it ($\chi^2(1) = 9.55$, $p = .002$) than participants who paid no attention to ads. Further, participants who reported distraction by the ads entered the ad above the text sooner ($\chi^2(1) = 5.00$, $p = .025$) than participants who did not report distraction. Moreover, there were interactions between abrupt onset of the ad above the text and reported attention to ads ($\chi^2(1) = 7.43$, $p = .006$) and reported distraction ($\chi^2(1) = 9.27$, $p = .002$) (see Figure 4). Participants who reported attention to ads had longer dwell times on the ad above in the no-onset condition than in the onset condition, whereas participant who did not report attention to ads had longer dwell times in the onset condition. Reported distraction showed an opposite pattern, that is, participants who reported distraction had longer dwell times in the onset condition.

Eye movements on the ad to the right of the text. On average, participants fixated the ad to the right of the text on 20% of the trials. The number of entries and fixations were higher for the ad on the right than for the ad above (see Figure 3). Abrupt onset did not affect eye movements toward the ad on the right (see Table 5). The self-report measures showed that participants who reported attention to ads had a higher number of entries ($\chi^2(1) = 18.24$, $p < .001$) and fixations ($\chi^2(1) = 27.45$, $p < .001$) toward the ad to the right than those who did not report attention to ads (see Table 6). Further, participants who reported distraction by the ads, fixated the ad on the right more often ($\chi^2(1) = 5.23$, $p = .022$) and had longer dwell times ($\chi^2(1) = 6.79$, $p = .009$) on it than those who did not report distraction.

The effect of abrupt ad onset. The time of first fixation (entry time) on the ad above the text was not correlated with the ad onset time, but such a correlation was observed for the ad on the right ($r = .482$, $p < .001$). The GEE model also revealed that abrupt onset affected the entry times for the ad on the right ($\chi^2(1) = 8.00$, $p = .005$), whereas a similar, but nonsignificant effect was observed for the ad above ($\chi^2(1) = 3.53$, $p = .060$). Figure 5 illustrates that both ads attracted more fixations during the first five fixations after an ad onset compared to fixations occurring later.

Table 4
The Effect of Abrupt Onset of Ads on Reading Measures in Experiment 2

	Ad above		Ad to the right	
	Onset	No-onset	Onset	No-onset
Reading performance				
Comprehension	.93	.89	.85	.89
Reading rate (wpm)	178.04	182.86	200.25	211.30
Eye movements on the text				
No. of entries	2.16	1.97	2.22	2.40
No. of fixations	108.30	106.22	109.64	108.62
No. of regressions	23.25	22.70	24.20	23.36
Time of entry (s)	.44	.46	.38	.47
MeanFixDur (ms)	260.66	260.56	265.77	264.40

Discussion

The purpose of Experiment 2 was to test how abrupt onsets of online ads affect reading and allocation of attention toward the ads. The results showed an association between the ad onset time and the time when the ad appearing to the right was fixated for the first time. Even though no such effect was observed for the ad above the text, the abrupt onset increased the number of entries and number of fixations toward it. In addition, both ads were fixated more often during the first five fixations after the ad onset than during later fixations. The results suggest that abrupt onset in the proximity of the text (i.e., to the right of it)

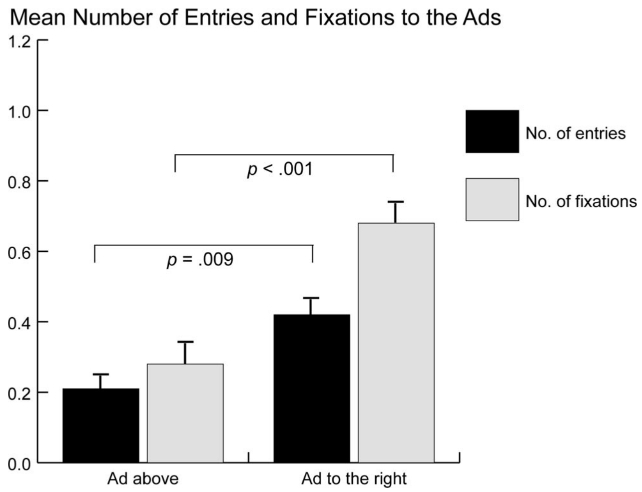

Figure 3. Number of entries and number of fixations to the ads in Experiment 2. Brackets indicate significant differences in Wilcoxon signed-ranks test. Error bars indicate *SE*.

captures more attention immediately, whereas abrupt onset in the visual periphery captures attention less immediately, but attention is nevertheless drawn toward the ad above the text more often when it appears abruptly. Furthermore, abrupt onset of the ad to the right of the text impaired comprehension accuracy more than abrupt onset of the ad above. However, comprehension was better when the ad above appeared abruptly compared to when it was present throughout the trial. This is an unexpected finding, possibly suggesting that an abrupt onset in the periphery increases attention toward the text and results in improved reading comprehension. Prior studies have reported similar findings suggesting that peripheral ads might increase users' level of arousal and motivate them to devote increased processing resources to the primary task (Burke et al., 2005; Day et al., 2006).

Ad location also affected reading performance. Comprehension was impaired more when an ad was shown to the right of the text than above it. On the other hand, reading was slower when an ad was presented above the text. Furthermore, slower reading was associated with improved comprehension. This effect was even stronger when an ad appeared to the right of the text. Improved comprehension was also associated with an increased number of fixations and regressions during reading, suggesting that a careful reading strategy resulted in better comprehension than a more superficial strategy. These results are generally in line with earlier findings on the relationship between eye movements and text memory (Hyönä, Lorch, & Kaakinen, 2002; Hyönä & Nurminen, 2006).

Table 5
The Effect of Abrupt Onset of Ads on Eye Movements to Ads in Experiment 2

	Ad above		Ad to the right	
	Onset	No-onset	Onset	No-onset
No. of entries	.36	.21	.48	.53
No. of fixations	.76	.54	1.27	1.30
Time of entry (s)	15.94	12.49	15.69	13.92
Dwell time (ms)	765.86	873.56	1,125.72	1,263.47

Table 6
The Relationship Between Participants' Self-Report Measures and the Eye Movement Measures for Ads in Experiment 2

	Attention		Distraction	
	Yes	No	Yes	No
Ad above text				
No. of entries	.28	.13	.26	.15
No. of fixations	.65	.16	.57	.25
Time of entry (s)	13.88	28.10	16.26	19.96
Dwell time (ms)	817.88	437.74	760.22	644.32
Ad to the right of text				
No. of entries	.44	.11	.40	.15
No. of fixations	1.12	.17	1.05	.25
Time of entry (s)	14.41	21.50	15.39	16.83
Dwell time (ms)	1,180.20	507.78	1216.29	604.60

Participants' gaze behavior was consistent with their self-reports, suggesting that participants who reported attention to ads also fixated the ads more often and for longer time than participants who did not report attention to ads. In addition, experienced ad distraction was associated with earlier fixations on the ad above as well as longer dwell time and greater number of fixations on the ad to the right. Experienced attention and ad distraction also interacted with the effect of abrupt ad onset, suggesting that abrupt onset increased experienced distraction as reflected in the eye movement measures (e.g., increased dwell time on the ad above the text). In contrast, reported attention to ads was associated with longer dwell time on the ad above in the no-onset condition, whereas participants who did not report attention to ads had longer dwell time on the ad above when it appeared abruptly. This suggests that participants who paid attention to ads were not affected by an abrupt onset, but instead looked at the ad above longer in the no-onset condition (possibly because the ads were visible for a longer time by being present throughout the trial). However, participants who did not pay attention to ads had longer dwell times on the ad above when it appeared abruptly, suggesting that for them abrupt onset produced an automatic attention capture resulting in longer dwell times on the ad above.

In Experiments 1 and 2, attentional allocation to online ads was studied when the users had to read texts surrounded by ads. However, the type of task users are engaged in may modulate the effects of animation or abrupt ad onset on attentional allocation. Experiment 3 examined the effect of task-orientation on the allocation of attention to online text and advertisements.

Experiment 3

Previous studies suggest that processing of online ads varies as a function of the difficulty of the primary task or task orientation. Zhang (2000) showed that the effect of animation was related to task difficulty so that animated ads influenced the performance of simple tasks more than that of more difficult tasks. Burke et al. (2005) also reported increased search times in the presence of

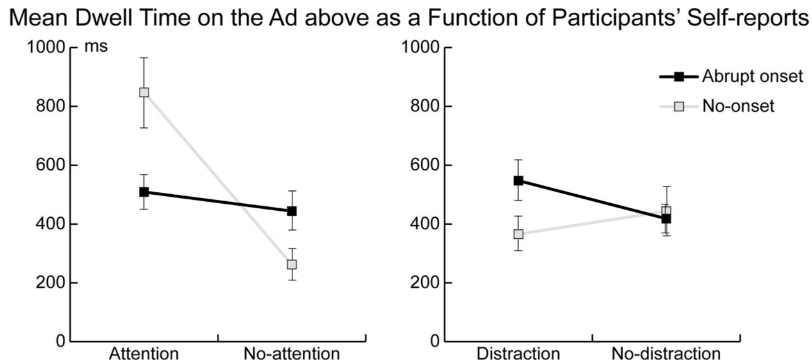

Figure 4. Interactions between abrupt onset and participants' self-reports for the dwell time on the ad above the text in Experiment 2. Error bars indicate *SE*.

commercial ads including colored graphics, when the task was to search for exact matches of given headlines (easy task) in comparison to when the sentence search task required semantic transformations (difficult task).

Experiment 3 was conducted to also provide guidelines for online advertisers as to what type of task conditions would benefit from using animation or abrupt ad onsets and when it may be better to avoid such design cues. Two tasks were compared to each other; in one, participants read the texts to answer text content questions (Experiment 3A) similarly to Experiment 1 and 2, while in the other task participants were asked to browse the Web pages according to their own interests (Experiment 3B). We expected that the free browsing task is supposedly easier than reading for comprehension, as it allows the participants to more freely distribute their visual attention across the Web page. To test how task-orientation affects attention to online ads, the following ad conditions were selected as examples of different Web page styles: An animated ad appeared above or to the right of the text after a random delay between 0–12 s, or both ads were presented simultaneously throughout the trial so that the ad above was static and the ad to the right of the text was animated (identical to the S + A condition of Experiment 1). Moreover, to assess the effect of ad presence, Experiment 3 included a baseline condition where no ads were presented, which was not the case in Experiment 1 and 2, where at least one ad was always present.

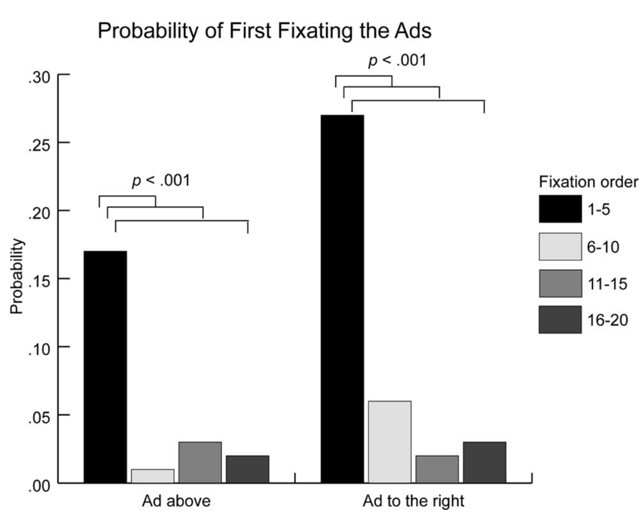

Figure 5. The probability of first fixating the ads at different ordinal fixation positions after abrupt onset of the ads in Experiment 2. Brackets indicate significant differences in *Z* test for two proportions.

Method

Participants. Thirty-two volunteers in Experiment 3A and 30 volunteers in Experiment 3B gave an informed consent and were paid to participate in the study (see Table 1). All had normal or corrected-to-normal vision. They were not aware of the purpose of the study, and none of them took part in Experiment 1 or 2.

Procedure. The same texts, advertisements and Web page layouts were used as in Experiments 1 and 2. The task in Experiment 3A was to read for comprehension. In Experiment 3B, participants were asked to browse the pages according to their own interest and subsequently report the main content of the page with a few words (i.e., we did not present text comprehension questions). The following ad conditions were used: (a) no ads present (baseline), (b) two ads present throughout the trial (the ad above was static and the ad to the right of the text was animated, S + A), (c) only an animated ad above the text was present after a random delay of 0–12 s (*A* + *blank*), (d) only an animated ad to the right of the text was present after a random delay of 0–12 s (*blank* + *A*).

Data analyses. To ensure compatibility of results with Experiments 1 and 2, similar procedures for data preprocessing and statistical analyses were used. The GEE model compared the fixations on the ad above the text between Conditions b and c, while the fixations on the ad on the right were compared between Conditions b and d. In addition, the effect of abrupt ad onset on attention toward the ads was tested similarly to Experiment 2.

Results of Experiments 3A and 3B were analyzed concurrently using a mixed design. Eye movement measures on the text region were subjected to repeated measures ANOVA with the task (i.e., experiment), participants' subjective reports of attention to ads and distraction by ads as between-participants factors and the ad condition as a within-participant factor. Around 56% of the participants in Experiment 3A and around 83% of the participants in Experiment 3B reported that they had paid attention to ads constantly or relatively often. Moreover, 69% of the participants in Experiment 3A and 77% of the participants in Experiment 3B reported that the ads distracted them constantly or relatively often. They formed the groups who reported attention to or distraction by ads. A similar design was used to analyze the results for the ad regions with the GEE-model.

The samples in the two experiments differed from each other in age ($t(60) = 3.22$, $p = .002$) and education ($t(60) = -3.06$, $p = .003$), suggesting that participants in Experiment 3A were older and less educated than participants in Experiment 3B (see Table 1). The samples did not differ in computer and Internet experience or in the frequency of Internet use. To control for the between-samples differences, age and education were included as factors in the pooled analyses of Experiment 3A and 3B. We first report how task and type of ad affected reading and attention toward the ads (i.e., fixations on the text and ad regions) and then how abrupt onsets captured attention.

Results

Reading performance, eye movements, and subjective reports. Reading rates differed between the tasks ($F(1, 56) = 14.03$, $p < .001$, $\eta_p^2 = .200$), suggesting faster reading when the task was to browse the pages according to participants' own interest (Experiment 3B) compared to the reading-for-comprehension task in Experiment 3A (see Table 7). Furthermore, the tasks differed from each other in the number of fixations ($F(1, 56) = 16.81$, $p < .001$, $\eta_p^2 = .231$), and in the number of regressions made in the text region ($F(1, 56) = 9.03$, $p = .004$, $\eta_p^2 = .139$), with fewer fixations and regressions in the free browsing than in the reading task. The text entry times showed a Task × Ad Condition interaction ($F(1, 56) = 4.99$, $p = .018$, $\eta_p^2 = .082$), suggesting that the text was entered later during free browsing than reading, but only in the condition where the ad above the text was static and the ad to the right of the text was animated (S + A) ($t(60) = 2.41$, $p = .023$, $d = .65$). Participants' self reports did not affect eye movements on the text region.

Eye movements on the ad above the text. In Experiment 3A, participants fixated the ad above the text in 11% of the trials, whereas in Experiment 3B the ad above was fixated in 32% of the trials. Figure 6 shows the mean number of entries and fixations to both ads. According to the GEE model, the ad above the text was entered ($\chi^2(1) = 16.57$, $p < .001$) and fixated ($\chi^2(1) = 12.13$, $p < .001$) more often during free browsing (Experiment 3B) than during reading (Experiment 3A) (see Table 8). In addition, the dwell time ($\chi^2(1) = 9.89$, $p = .002$) on the ad above was longer during free browsing than during reading. There was also a Task × Ad Condition interaction ($\chi^2(1) = 6.20$, $p = .013$) in the entry time, suggesting that the ad above was entered later during the free browsing task when the ad was animated and appeared abruptly compared to the S + A condition ($p = .036$), while in the reading task the entry times on the ad above did not differ between the ad conditions.

Self-reported attention to ads was associated with the number of entries ($\chi^2(1) = 18.75$, $p < .001$) and number of fixations ($\chi^2(1) = 20.80$, $p < .001$) on the ad above the text. These observations suggested more entries and fixations (.49 ± 1.15 *SD* and 1.10 ± 2.97 *SD*) on the ad above for participants who reported attention to ads than for participants who did not report attention to ads (.13 ± .48 *SD* and .24 ± 1.26 *SD*, respectively).

Eye movements on the ad to the right of the text. In Experiment 3A, participants fixated the ad to the right of the text in 23% of the trials, whereas participants in Experiment 3B fixated the ad to the right in 33% of the trials. In both tasks, the number

Table 7
Means of Reading Performance and Eye Movement Measures in Experiment 3, as a Function of Task (Exp. 3A: Reading vs. Exp. 3B: Free Browsing) and Studied Conditions

Ad condition	Baseline	S + A	A + blank	Blank + A
Comprehension				
Exp. 3A	.81	.87	.84	.77
Reading rate (wpm)				
Exp. 3A	173.73	169.16	169.74	163.60
Exp. 3B	282.37	291.39	283.59	287.09
No. of entries				
Exp. 3A	1.95	2.02	2.00	2.54
Exp. 3B	2.63	3.31	2.77	3.43
No. of fixations				
Exp. 3A	109.55	110.32	111.44	113.40
Exp. 3B	82.45	78.62	81.92	81.77
No. of regressions				
Exp. 3A	23.33	23.00	23.14	24.12
Exp. 3B	17.31	16.49	17.52	17.52
Time of entry (s)				
Exp. 3A	.34	.40	.37	.36
Exp. 3B	.39	.92	.52	.42
MeanFixDur (ms)				
Exp. 3A	277.76	281.61	276.48	282.17
Exp. 3B	258.74	261.73	262.21	262.01

Note. Baseline = no ads were presented; S + A = the ad above was static and the ad to the right was animated (the same condition as in Experiment 1); A + Blank = only the ad above (animated) appeared after a random delay of 0–12 s; Blank + A = only the ad to the right (animated) appeared after a random delay of 0–12 s.

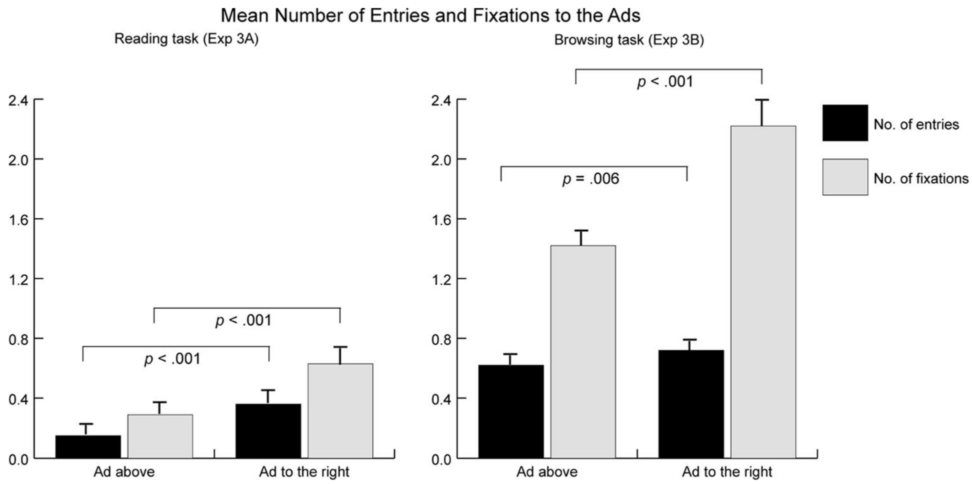

Figure 6. Number of entries and number of fixations toward the ads in Experiment 3. Brackets indicate significant differences in Wilcoxon signed-ranks test. Error bars indicate *SE*.

of entries and fixations were higher for the ad on the right than above the text (see Figure 6). The number of entries ($\chi^2(1) = 6.43$, $p = .011$) and the number of fixations ($\chi^2(1) = 12.15$, $p < .001$) toward the ad on the right differed between the tasks, suggesting more frequent entries and fixations in the free browsing than in the reading task (see Table 8). In addition, the dwell time ($\chi^2(1) = 20.02$, $p < .001$) on the ad on the right was longer during free browsing than during reading. We also observed a Task × Ad Condition interaction in the number of entries ($\chi^2(1) = 4.50$, $p = .025$) and entry times ($\chi^2(1) = 6.99$, $p = .008$) toward the ad to the right of the text. These interactions suggest that in the S + A condition the ad on the right was fixated more often ($p = .009$) and earlier ($p = .032$) during free browsing than during reading.

Table 8
The Effect of Ad Condition on Eye Movements to Ads in Experiment 3, as a Function of Task (Exp. 3A: Reading vs. Exp. 3B: Free Browsing) and Studied Conditions

	Ad above		Ad to the right	
	A + blank	S + A	Blank + A	S + A
No. of entries				
Exp. 3A	.19	.13	.68	.47
Exp. 3B	.91	.84	1.42	1.37
No. of fixations				
Exp. 3A	.40	.29	1.25	.95
Exp. 3B	2.30	2.15	4.56	4.21
Time of entry (s)				
Exp. 3A	12.27	20.62	19.25	20.69
Exp. 3B	17.30	11.56	14.11	8.90
Dwell time (ms)				
Exp. 3A	680.96	1015.09	882.69	
Exp. 3B	1,184.82	2,309.41	2,057.30	

Note. A + Blank = only the ad above (animated) appeared after a random delay of 0–12 s; S + A = the ad above was static and the ad to the right was animated; Blank + A = only the ad to the right (animated) appeared after a random delay of 0–12 s.

Self-reported attention to ads was associated with the number of entries ($\chi^2(1) = 7.13$, $p = .008$), number of fixations ($\chi^2(1) = 15.97$, $p < .001$), and dwell time ($\chi^2(1) = 15.41$, $p < .001$) on the ad to the right of the text. These observations suggest more frequent entries (2.08 ± 1.47 *SD*), fixations (5.87 ± 6.60 *SD*), and longer dwell time (1799.41 ± 2046.33 *SD*) on the ad on the right for participants who reported paying attention to the ads compared to participants who did not report attention to the ads (1.48 ± 1.00 *SD*, 2.27 ± 3.43 *SD*, and 621.77 ± 718.45 *SD*).

The effects of abrupt ad onset. The time of the first fixation landing on the ad above was not associated with the ad onset time in Experiment 3A; however, in Experiment 3B the ad onset time correlated with the time of first fixation ($r = .256$, $p = .011$). The GEE model showed that in both experiments, the number of entries ($\chi^2(1) = 4.13$, $p = .042$) and the dwell time on the ad above the text ($\chi^2(1) = 4.58$, $p = .032$) were associated with its abrupt onset time.

For the ad to the right, correlations between the ad onset time and the time of first fixation were observed in both experiments (3A: $r = .246$, $p = .014$; 3B: $r = .520$, $p < .001$). Moreover, the GEE model indicated that the ad onset time was associated with the time of first fixation landing on it ($\chi^2(1) = 7.64$, $p = .006$). Figure 7 illustrates that the ads attracted more fixations during the first five fixations after an ad onset compared to later occurring fixations (except for the ad above in Experiment 3A).

To examine the effect of task on attentional capture by abrupt ad onset, the number of intervening fixations between the ad onset and observers' first fixation on the ad was compared between Experiments 3A and 3B. The task did not affect the number of fixations between the ad onset and the time of first fixation on the ad above. However, the ad on the right was fixated earlier after its onset in the free browsing than in the reading task ($\chi^2(1) = 11.11$, $p = .001$). Moreover, the probability of first fixation on the ad on the right occurring during the first five fixations ($Z = 1.66$, $p < .05$) or during the fixation sequence of 6–10 ($Z = 1.66$, $p < .05$) after its onset was higher in Experiment 3B than in Experiment 3A

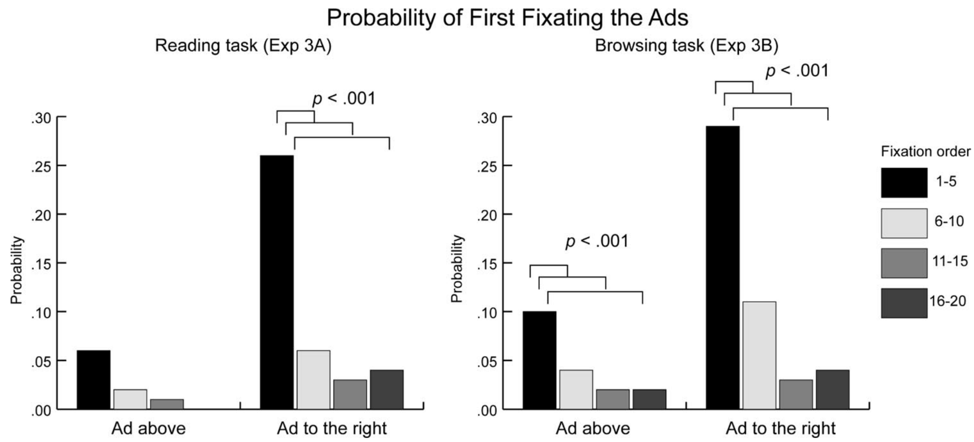

Figure 7. The probability of first fixating the ads at different ordinal fixation positions after the abrupt onset of either the ad above or the ad to the right of the text. In Experiment 3A, the task was to read the texts for comprehension, and in Experiment 3B the participants were asked to browse the Web pages according to their interest. Brackets indicate significant differences in *Z* test for two proportions.

(see Figure 7). No task differences were observed when an animated ad appeared abruptly above the text.

Discussion

Participants paid more attention to ads in Experiment 3B where the task was to browse the pages according to their own interest compared to Experiment 3A where the task was to read for comprehension. This was shown by more frequent eye entries and fixations as well as longer dwell times on the ads in Experiment 3B than in Experiment 3A. Moreover, the task instruction affected eye movements during text reading, suggesting more superficial reading when the task was to browse the pages compared to a more careful reading strategy required in Experiment 3A, where participants were instructed to read for comprehension. This was reflected in faster reading rates in Experiment 3B and increased number of fixations and regressions on the text region in Experiment 3A. Comparisons between the experiments also showed that when both ads were present throughout the trial (the S + A condition), the text was entered earlier in the reading-for-comprehension than in the free browsing task. An early text entry in the reading task makes sense because the task instructions made the text relevant and the ads irrelevant for the task.

In the free browsing task, we observed a correlation between the abrupt onset time of both ads and the time when the participants first fixated an ad, whereas in the reading task such an effect was observed only for the ad on the right. The result supports the conclusion that during reading an abrupt ad onset in the proximity of the text captures attention efficiently, whereas an ad onset does not produce an immediate attention capture when the ad appears further in the visual periphery. These results are consistent with those obtained in Experiment 2 (also using a reading task), where the abrupt onset of the ad on the right was associated with the time of first fixations to it, while no such effect was observed for the ad above the text.[3]

The results of Experiment 3 also suggest that participants' self-reports are compatible with their actual eye behavior. That is, participants who reported paying attention to ads had more frequent entries and fixations on both ads, as well as longer dwell time on the ad to the right than participants who did not report attention to ads. Moreover, the results of Experiment 3 indicate that the mere presence of ads did not interfere with reading, because the baseline condition where no ads were present did not prove to be better in any of the reading measures. This finding, combined with other findings of the present study, supports the hypothesis that distraction by ads primarily occurs through overt attention to ads rather than through covert processing.

The ad's location in relation to the text appeared to be a relevant factor. An abrupt onset of the ad above the text did not distract reading, whereas the onset of the ad to the right captured attention. This is presumably because of the proximity of the ad on the right with respect to the ends of text lines. Thus, when reading a text participants frequently approach the ad on the right, thus increasing the likelihood of the ad capturing attention. Or put it differently, when Web users focus their attention on the reading task, they are more capable of overriding the attentional capture by abrupt ad onsets when an ad appears in a peripheral location than when it appears in the proximity of the main task area. This conclusion is inconsistent with the study of Stenfors et al. (2003), who suggest that novel stimuli as such do not attract attention in the Web environment, because participants are likely to learn the ad locations and consequently do not pay attention to task-irrelevant stimuli presented in predictable locations. It should be noted, however, that Stenfors et al. studied only the effects of ads appearing on the top of the screen in a visual cuing task where the color of a central cue indicated the location of a forthcoming lateral target. The top location of an ad in the present experiments proved to attract less attention than the ads located on the right side of the Web pages. However, the location effects may be qualified

[3] It may be noted, however, that the comparisons between the abrupt onset conditions and the S + A condition are not as solid as in Experiment 2, where only one ad was present at a time and the effect of an abrupt onset was compared with the same ad when present throughout the trial.

by task conditions, that is, in some tasks the upper part of a Web page may be task-relevant.

General Discussion

The present study investigated how Web users allocate attention toward advertisements during text reading (and free browsing). We manipulated the combination of animated and static ads presented simultaneously in the periphery and in the proximity of the text region. Moreover, the ads appeared on the screen together with the text either in the beginning of the trial or abruptly after some delay. Finally, we manipulated the nature of the primary task. In Experiment 1, 2, and 3A, the task was to read the texts for comprehension and the comprehension accuracy was tested after each text. In Experiment 3B, participants were instructed to browse the Web pages according to their own interests and briefly report the main content of the page. Allocation of attention was examined by registering participants' eye movements to measure the extent to which ads capture attention during reading and whether the presence of ads affects online reading behavior. The former case refers to overt attentional capture by ads, while the latter case reflects covert allocation of attentional resources. In the analyses, participants' self-reports on experienced attention to ads and distraction by them were compared with their actual eye movement behavior.

The main results of the present study may be summarized as follows: (a) Contrary to some earlier studies, we found that online ads are not ignored during reading, irrespective of whether the task was engaging (reading for comprehension) or free browsing. In our experiments, the ads were overtly and not only covertly attended. This was shown in that the effects of ads on reading were always accompanied by similar effects obtained for overt attention to ads. (b) Animation distracted reading especially when a combination of static and animated ad was presented. Such conditions led to increased attentional capture relative to conditions where both ads were static or animated. (c) Abrupt onset of ads during reading captured attention, but this effect was modulated by ad location and task-orientation. (d) Ads located immediately to the right of the text region produced a greater attentional capture than ads positioned above the text region. (e) The ads were attended to more during a free browsing than during a reading task. Moreover, attentional capture by abrupt onset of both ads was observed in the free browsing task, whereas in the reading-for-comprehension task, only the abrupt onset of the ad to the right of the text captured attention. In the following, we discuss each finding in more detail.

The finding that an effect of ads on reading was always accompanied by eye fixations on ads is in line with the view that attentional capture by ads is primarily related to mechanisms of overt attention. This finding runs counter to studies (Burke et al., 2005; Day et al., 2006; Drèze & Hussherr, 2003), suggesting that online ad processing occurs mostly peripherally via the covert attention mechanism. The fact that the ad conditions had only a slight effect on reading eye movements further supports the hypothesis that distraction by ads occurs through overt fixations toward the ads rather than as covert processing of ads. However, the finding in Experiment 1 that only the ad above the text influenced reading possibly reflects the fact that the ad to the right was attended more than the ad above. In other words, the ad on the right affected overt attentional allocation, while the ad above possibly exerted its influence also via covert attentional allocation (i.e., its influence was less robust). Corroborative evidence in support of the overt attentional mechanism being significantly involved comes from the participants' retrospective verbal reports that were consistent with their actual eye behavior. Furthermore, comprehension accuracy was in line with eye movement results, that is, accuracy improved by a slow reading rate, indicating that a careful reading strategy (also indexed by frequent fixations and regressions during reading) resulted in better comprehension than a more superficial strategy.

The result that a combination of one static and one animated ad increased attentional capture is an interesting but surprising finding, as we expected two animated ads to produce the most attentional capture. It is likely that when two animated ads are present simultaneously, they are equally salient (both contain motion) and thus compete with equal strength for users' attentional resources. Moreover, increased saliency of ads is likely to be accompanied by increased attentional resources being invested in ignoring task-irrelevant stimuli. As a consequence, two animated ads are ignored by top-down attention as effectively as two static ones, but when only one of the ads is animated, it is individually more salient and is thus more likely to capture attention. This finding suggests that to secure good reading performance, displaying one animated ad in the presence of a static ad should be avoided, as such displays prevent readers from ignoring distraction by task-irrelevant stimuli. For advertisers the results suggest that to attract attention in cluttered Web pages, several animated ads should not be presented simultaneously, because an excessive use of animation seems to help users avoid task-irrelevant information. However, the underlying attentional mechanism, that is, whether suppression of task-irrelevant ad information or enhanced processing of relevant text information is involved, is beyond the scope of the present study and needs more empirical evidence.

Another major finding was that abrupt ad onsets capture attention, but the effect depends on the ad location and task-orientation. This suggests that when engaged in a reading task, Web users can ignore abrupt stimulus onsets in the periphery but not in the proximity of the main task area. The use of an avoidance strategy was probably boosted by the fact that the ads always appeared in the same two locations, so their location was highly predictable and thus easier to ignore (cf. Theeuwes & Burger, 1998). In future studies, it would be interesting to study the effects of abrupt onsets of ads appearing in multiple, less predictable locations.

The ads located close to the right border of the text were attended to more than ads above the text. This suggests that motion or abrupt onset attract users' visual attention toward ads when they frequently approach the ads with their eyes. This happens every time readers fixate the ends of text lines located in the proximity of the ad. When an ad is positioned above the text, readers' gaze does not approach it; instead, the further they advance in the text the longer away their gaze is from the ad. Thus, to prevent users from unintentionally attending to animated ads, the ads should be positioned as far away as possible from the display area the users are likely to gaze at. Ad positioning, however, depends on the goals of the online content providers, because the Web page publisher may also want to direct attention toward the ads. In that case, the position to the right of the text is the most effective location. Similarly, previous research has reported that ads located close to the main task area or in the lower visual field are beneficial for advertising efficiency measured in terms of perception of and memory for ads (Kuisma et al., 2010) or brand attitude (Goodrich, 2010). It should be noted, however, that the design of the present experiments could not disentangle the effects of ad location and format from each other, because the ad to the right was always vertical and the ad above was horizontal.

One of the main findings was that more attention was allocated to ads when task constraints were less stringent (free browsing). Furthermore, during free browsing we obtained evidence for attentional capture by abrupt onsets of ads appearing in the two studied locations. Combined with the previous findings, these observations suggest that the current goal of Web users can exert a strong top-down influence on attentional allocation during Web browsing so that the presence of ads and their abrupt onsets attract more attention during a free browsing than during a reading task. This was also reflected in the participants' verbal reports: over 80% of the participants in the free browsing task paid attention to ads, whereas only around 40–50% of the participants in the reading task reported that the ads had attracted their attention. Thus, in line with other authors (Rayner et al., 2008; Wedel et al., 2008), we suggest that advertisers should consider the users' key goals when selecting the format and placement for online ads. This perspective is largely ignored by the advertising research that has so far mainly emphasized how specific layout and content elements of ads influence viewers' gaze, assuming that only bottom-up attentional patterns matter.

From the theoretical perspective, the present study demonstrated that findings from basic attention research and the theories of visual attention derived from them, especially research pointing to the significance of visual saliency (Itti & Koch, 2000), the distinction between bottom-up versus top-down control of attention (Theeuwes, 1994; Theeuwes & Burger, 1998), the principles of the central capacity theory (Kahneman, 1973), and the research related to abrupt stimulus onsets (e.g., Theeuwes et al., 1999; Yantis & Jonides, 1984) can be successfully applied also to the Web environment when the influences of advertising are studied. This is relevant, as arguments to the contrary have been made (Diaper & Waelend, 2000; Zhang, 2000).

Finally, the present study provides important practical suggestions for efficient Web design. The suggestions are in line with the view proposed by Rosen and Purinton (2004) in that we believe the development of effective and user-friendly Web designs can be significantly assisted by utilizing perspectives offered by cognitive psychology. Given a choice, content providers and online advertisers should prefer ad formats and context that only minimally disturb users' main task because, as previous studies have shown, distraction can lead into irritation and unfavorable attitudes toward a Website (e.g., Gao et al., 2004). As practical implications for minimizing the distraction by ads, the findings from the present experiments can be summarized as follows: If more than one ad is presented on the screen simultaneously, they should all be either animated or static, to allow users to efficiently ignore task-irrelevant ad information. Preferably, the ads should not be placed in the close proximity of the main task area, because ads presented close to the main task area capture attention and result in disruptions to the main task. Users' task and variations in task load should be considered when placing ads on Web pages. Our results demonstrate that ads capture more attention during a free browsing task than when reading for comprehension.

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Correction to Beck et al. (2010)

In the article "Measuring Search Efficiency in Complex Visual Search Tasks: Global and Local Clutter," by Melissa R. Beck, Maura C. Lohrenz, and J. Gregory Taflon (*Journal of Experimental Psychology: Applied*, Vol. 16, No. 3, pp. 238–250), the copyright for the article was incorrectly listed. The article is in the public domain.

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