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RESEARCH ARTICLE

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The Impact of Animated Banner Ads on Online Consumers: A Feature-Level Analysis Using Eye Tracking

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Abstract

Despite the popular use of animated banner ads on websites, extant research on the effects of web animation has generated mixed results. We argue that it is critical to identify feature-level animation characteristics and examine their individual and combined effects on capturing online consumers' attention across different task conditions. We identify three key animation features (i.e., motion, lagging, and looming) based on three attention theories and investigate their effects on online consumers' attention and recall across browsing and searching tasks in three laboratory experiments using an eye tracking machine. Experiment 1 found that both motion and looming (animation features) are effective in attracting online consumers' attention to animated ads when they are performing a browsing task. However, combining a salient feature (e.g., motion) with another salient feature (e.g., looming) does not improve the original attention attraction effect, suggesting a "banner saturation" effect. Further, we found that online consumers' attention positively affects their recall performance. In Experiment 2, none of the animation features or their interactions had a significant effect when the subjects were performing a searching task, indicating that task is an important boundary condition when applying attention theories. Experiment 3 replicated Experiment 1 in a more realistic context and produced similar results. We conclude the paper by discussing theoretical and practical implications as well as avenues for future research.

Keywords: Online Consumers, Online Advertisement, Website Design, Animation, Banner Ads, Attention, Eye Tracking, Human-Computer Interaction

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1 Introduction

Since the first banner advertisement (ad) appeared in 1994, internet advertising revenue (generated by different advertising formats including banner ads and animated ads) in the US has grown from US$1.8 billion in 1998 to US$124.6 billion in 2019 (Interactive Advertising Bureau, 2020). However, online banner ads are not "the advertising industry's most glorious achievement" (Harford, 2015), as their effectiveness has always been controversial. Online advertisement is a major revenue source for many websites, including big players like Google and Facebook. But it remains unclear whether animation draws attention to online ads or drives away attention. Microsoft conducted a study on 72 animated ads and 72 static ads derived from the final frame of the animations and found that animated ads are perceived as more annoying than their static counterparts (Harford, 2015). But the fact that animated banner ads are still widely used (Appendix Figures A1a-A1c present animated ads used on some of the Alexa 2020's top 50 websites) indicates that advertisers still expect animation to attract more attention. Unfortunately, this expectation is not well supported by extant research on the effectiveness of animated ads, and some researchers have even found a phenomenon termed "banner blindness" (Bayles, 2002; Benway & Lane, 1998; Burke et al., 2005; Dreze & Hussherr, 2003; Robinson, Wysocka, & Hand, 2007), describing situations in which consumers consciously avoid looking at animated banner ads.

On the one hand, the effectiveness of animation in attracting attention remains uncertain; on the other hand, it is commonly accepted that highly annoying ads can drive online consumers away. In February 2018, Google incorporated a built-in ad blocker in Chrome, the most popular web browser, to automatically block all ads that do not comply with the better ads standards set by the Coalition for Better Ads (BBC News, 2018). Not surprisingly, the majority of ads contain some form of animation, such as pop-up ads and flashing animated ads (Coalition for Better Ads, 2019). Thus, the challenges that websites face are twofold: ensuring the effectiveness of animated ads in attracting attention while at the same time, ensuring that they are not too annoying or intrusive to online consumers.

The popularity of web animation and the debate over its effectiveness has drawn attention from researchers in various disciplines, including information systems (e.g., Cheung, Hong, & Thong, 2017; Lai et al., 2009; Lee & Ahn, 2012; Zorn et al., 2012), human-computer interaction (e.g., Burke et al., 2005), marketing (e.g., Kuisma et al., 2010), and communications (e.g., Diao & Sundar, 2004). Unfortunately, the findings from these studies do not provide a consensus on the effectiveness of animation. Although some studies have concluded that animation attracts attention, leads to better recall of the animated content or higher click-through rates (e.g., Lohtia, Donthu, & Hershberger, 2003; Rau, Chen, & Chen, 2006; Yoo, Kim, & Stout, 2004; Zorn et al., 2012), others have found that animation either has no effect (e.g., Bayles, 2002; Diaper & Waelend, 2000; Dreze & Hussherr, 2003; Kuisma et al., 2010; Robinson et al., 2007) or has negative effects on visual search performance, recall of animated content, and attitudes toward the ads or the website (e.g., Burke et al., 2004; Burke et al., 2005; Gao, Koufaris, & Ducoffe, 2004; Josephson, 2005; Lee & Ahn, 2012; Rau, Gao, & Liu, 2007). We argue that there are a few reasons for the inconsistent findings in prior research.

First, different animation features are used in different studies, making it difficult to compare the results of one study with those of another. Under the umbrella term of "animation", different studies have examined different animation features (see Appendix Table B1 for a summary), indicating that the effects of animation vary by design (e.g., some animation features may be subtle and thus less effective at attracting attention, some may be nonintrusive but effectively attract attention, and others may effectively attract attention but annoy consumers with their intrusiveness). To make it even more difficult to consolidate prior findings, many animated ads possess multiple animation features, such as simultaneous motion and color changes. Hence, we argue that it is critical to tease out the effects of animation at the feature level and examine their effects individually and in combination with one another. Only by doing this is it possible to provide a foundation for consolidating prior research findings and advancing research on web animation.

Second, a variety of theories have been used in prior studies, including but not limited to, central capacity theory (Kahneman, 1973), bio-informational theory of emotion (Lang, 1995), limited capacity theory of information processing (Lang, 2000), motion effect theory (Reeves & Nass, 1996), executive function theory (Miller & Cohen, 2001), and distinctiveness theory (Gati & Tversky, 1987; Nairne et al., 1997). While these theories improve the understanding of the effect of animation in general, most of them do not enable researchers to identify the animation explicitly at the feature level (except for motion effect theory, which states that on-screen and real-life motion can provoke the same physical responses). As argued above, we believe that it is critical to identify theories that can help tease out animation at the feature level. We reviewed the visual attention theories developed in psychology (see Appendix Table C1) and identified three theories that are particularly relevant to animation features—*dynamic default theory* (Folk, Remington, & Johnston, 1992), *new object theory* (Hillstrom & Yantis, 1994), and *behavioral urgency theory* (Franconeri & Simons, 2003)—each of these theories allowed us to identify one animation feature. We then examined interaction effects among these animation features to advance our understanding of how online consumers respond to animation with multiple features.

Third, the conflicting findings may be due to the variety of tasks performed by online consumers. The majority of prior animation studies typically examine the effects of animation in a single task condition and these findings may not replicate under different task conditions. Some prior studies have highlighted that online consumers' tasks have different impacts on the effectiveness of animation (e.g., Burke et al., 2005; Hong, Thong, & Tam, 2007) and should thus be taken into account in evaluating the results. Hence, research on web animation needs to examine the effects of the same animation under different task conditions. Research that systematically varies the features of animation under different task conditions is essential for building a consolidated understanding of the effects of web animation on attracting online consumers' attention.

Finally, the inconsistent results may be due to the difficulty of accurately measuring online consumers' attention. The majority of prior studies employ a variety of dependent measures as indicators of online consumers' attention, most of which are based on self-reported data such as recall (e.g., Gao et al., 2004; Jiang, Lim, & Sun, 2009; Rau et al., 2006; Yoo & Kim, 2005). However, such data represent a higher level of cognitive activity that requires decoding, processing, and storing information in addition to visual attention. Some researchers (e.g., Goldberg et al., 2002; Graf & Krueger, 1989; Rau et al., 2007) have called for the use of objective data to help validate the findings based on questionnaire data currently prevalent in the field. For instance, eye tracking technology can be used to provide objective data on individuals' eye movements (e.g., Cheung et al., 2017; Cyr et al., 2009; Dabbish & Kraut, 2008) which are good indicators of individuals' attention (Goldberg & Kotval, 1999; Henderson, 1992).

In short, in order to reconcile inconsistent findings of prior animation research and to help web designers better understand the effects of animation beyond the easy-to-measure click-through rate, there is a need to identify and utilize visual attention theories that specifically target animation at the feature level and apply these theories to the examination of one or more animation features under different task conditions, using both subjective recall data and objective eye tracking data. Based on this background, we investigate three research questions in this paper:

RQ1: Which animation features are theoretically supported, and how do they impact online consumers' visual attention and subsequently recall performance?

RQ2: How do different animation features interact with each other?

RQ3: How do the impacts of different animation features vary under different online tasks?

To answer the above research questions, we identify three key features of animation and theorize how these features may have individual and/or interaction effects on online consumers' attention. We believe that identifying such lower-level animation features can help consolidate the results of prior studies on animation: for example, rolling text and a waving sign can both be considered to be motion, while a flat text that stands up can be considered to be both motion and looming. Thus, labeling each animated ad against these key features enables comparison of results across different studies.

In this study, we conducted three experiments. We systematically varied the online tasks assigned to sample consumers for each animated ad in order to gain a more complete understanding of its effect. Our third experiment validates (and provide evidence of external validity) the effects of animated ads in a more realistic context using a more complex design (that mimics a real-life online interface), in contrast to the simpler design used in the first two experiments (where the objective was to maximize internal validity). Lastly, we used an eye tracking machine to track online consumers' real-time visual attention and then assessed their recall of the animated banner ad to gain a deeper understanding of the effects of animation. In summary, we assessed the effects of animation features across three experiments involving two online tasks (i.e., browsing and searching), two contexts (i.e., a relatively simple website and a more realistic website), and two experiment designs (a within-subject design and a between-subject design).

2 Literature Review

We summarize our review of the literature on web animation in Appendix Table B1. In reviewing the literature, we focused on the features of animation implemented, the task condition(s) examined, and the main dependent variables of interest. Based on our analysis, we arrived at three observations. The first observation is that animation has been implemented in a variety of ways, including flashing texts (Hong, Thong, & Tam, 2004a; Hong et al., 2007), moving or rotating texts (Bayles, 2002; Hamborg et al., 2012), applying moving water waves in the background of texts (Cheung et al., 2017), changing frames (Cho, 2003; Lee & Ahn, 2012; Lee, Ahn, & Park, 2015), and so on. Animated ads that are visually different may have different impacts on online consumers' visual attention, making it difficult to compare results based on one type of animation to those based on another. To complicate matters, some studies have used animated ads taken from the web (Burke et al., 2005; Diao & Sundar, 2004; Diaper & Waelend, 2000; Kuisma et al., 2010; Lang et al., 2002). Usually, there is a lack of description of the design and the features of these commercial animated ads (e.g., Baltas, 2003; Dreze & Hussherr, 2003; Li & Bukovac, 1999), which makes it difficult to draw inferences about the features of the animation. Even when screenshots of animated ads are provided, it is difficult to disentangle the animation features used from static images. Further, since commercial animated ads typically combine several animation features, it is not possible for researchers to tease their impacts apart in the analyses (i.e., each animation feature may contribute differently to the overall effect). As a result, the generalizability of the findings of these studies is difficult to ascertain. In summary, fundamental research is needed to identify the key features of animation, which will then allow researchers to investigate the effects of different animation features on a more consistent basis.

A second observation is that it is essential to examine the task conditions under which animation was studied. In Appendix Table B1, even though we classified most of the experiment tasks into searching and browsing tasks, specific tasks differ across studies. For example, different studies manipulated searching tasks as, respectively, searching for a particular string among unordered phrases (Zhang, 2000), searching for a product to buy on a retailer website (Hong et al., 2004a; 2007), searching for product information to help a friend choose a digital camera (Gao et al., 2004), or searching for information about a movie for a friend (Hamborg et al., 2012). Similarly, browsing tasks have been respectively manipulated as aimless surfing on websites (Pagendarm & Schaumburg, 2001), evaluating a website design (Yoo & Kim, 2005), browsing for products to buy (Cheung et al., 2017), or simply reading a series of headlines (Lang et al., 2002), texts (Kuisma et al., 2010), or news pages (Lee & Ahn, 2012; Lee et al., 2015). Despite the variety of task manipulations across studies, when searching and browsing tasks are examined together in one study, the results typically indicate stronger effects for animation under browsing conditions than under searching conditions (e.g., Cheung et al., 2017; Hong et al., 2007; Pagendarm & Schaumburg, 2001). This suggests that a particular animation feature with significant effects in one task condition may not have the same effect in a different task condition. Hence, it is critical to examine the same animation feature under different task conditions in order to derive a fuller understanding of its effects.

A final observation is that the main dependent variables used to capture attention can be classified into two main categories: objective measures that can be captured by systems, such as searching time and accuracy, and subjective measures that are reported by the subjects, such as recall of animated ads and attitude toward the website. While both types of dependent variables provide inferences on the effects of animation for attracting attention, most animation studies do not include direct measurement of individuals' visual attention, which would require the use of an eye tracking machine (with few exceptions such as Burke et al., 2005, Cheung et al., 2017, and Josephson, 2005). The scarcity of eye tracking data in animation research may be a result of the difficulty in collecting (one subject at a time) and analyzing the data (high volume of eye tracking data and need for specialized software). Recently, more studies have been using eye tracking machines. For example, eye tracking machines were used to study web design features and objects (Dabbish & Kraut, 2008; Djamasbi, Siegel, & Tullis, 2010), such as human images (Cyr et al., 2009). These studies show that using an eye tracking machine offers researchers deeper and clearer insights into online consumers' viewing patterns and can help pinpoint the effects of specific design features. We believe that eye tracking data are also critical for animation studies because they not only enable direct measurement of individuals' attention, but they also serve as a bridge between the display and the processing of visual stimuli (Goldberg & Kotval, 1999; Henderson, 1992; Rau et al., 2006). Hence, incorporating eye tracking data with subjective measures can enrich our understanding of the effects of animation on attracting online consumers' attention.

3 Theoretical Background and Hypotheses

3.1 Attention Theories

To tease apart complex animation effects into specific animation features, we first review the cognitive psychology theories on visual attention (also see Appendix Table C1) which describe how salient features attract individuals' attention. These theories argue that a salient feature may attract attention because of its dynamics (Folk et al., 1992), distinctiveness (Gati & Tversky, 1987; Nairne et al., 1997), contrast with immediate neighbors (Duncan & Humphreys, 1989; Nothdurft, 1993a), pre-attentive processibility (Treisman, 1986; Treisman & Gelade, 1980), etc. However, many of these theories focus on static features, such as color and orientation (e.g., feature integration theory, similarity-based theory, and local feature contrast theory), or do not differentiate between static and dynamic features (e.g., distinctiveness theory, guided search model, and visual saliency theory). Hence, we chose three theories that we found to be most relevant and directly applicable to the understanding of how dynamic features (i.e., animation) attract the attention of online consumers, i.e., *dynamic default theory* (Folk et al., 1992), *new object theory* (Hillstrom & Yantis, 1994) and *behavioral urgency theory* (Franconeri & Simons, 2003). These three theories were developed over time to explain why certain dynamic features (or animation) are better at attracting attention than others.

First, *dynamic default theory* (Folk et al., 1992) proposes that the attention allocation system can be "configured" or "set" to respond selectively to different salient features in the context of different behavioral goals—i.e., the corresponding attentional control settings will be customized to different behavioral goals. If the behavioral goal is to search for a target with a specific salient feature (such as a green letter), then that salient feature will be included in the attentional control setting, which gives it a better chance of getting attention than other salient features (such as a letter that is large in size). When individuals have little motivation to focus their attention on a specific salient feature, the theory claims that dynamic features such as motion can gain attentional priority through the "default" attentional control setting. While dynamic default theory suggests that any dynamic feature will garner attentional priority by default, *new object theory* (Hillstrom & Yantis, 1994) argues that only the abrupt appearance of a new object garners attentional priority by default. Abrupt onset is defined as the sudden appearance of a new object in an originally blank visual field. Hillstrom and Yantis (1994, p. 96) propose that the introduction of new objects in the visual field attracts special attention, because "the appearance of new objects, and the observer's ability to detect and respond to them, has adaptive significance for visually guided organisms." This theory helps to explain the observation that *abrupt onset* has a unique ability to attract visual attention, as compared to other salient features such as luminance and hue (Jonides & Yantis, 1988). It has the unique ability to attract attention because it forms a new perceptual object in the visual field. To consolidate dynamic default theory and new object theory, Franconeri and Simons (2003) proposed *behavioral urgency theory*, which argues that stimuli that potentially signal behavioral urgency are more likely to receive attentional priority. Whenever a dynamic feature or the abrupt appearance of a new object signals the potential need for an immediate response, attention will be attracted.

These three theories are competing yet complementary theories in the sense that, although they provide different explanations for why a dynamic feature attracts attention, these explanations are not mutually exclusive. Indeed, for the same dynamic feature, different theories may offer different explanations on why it attracts attention (e.g., a rolling text banner may attract attention because it is dynamic in nature or because it is typically applied to important messages such as warnings). Later theories typically provide new explanations of previous findings or provide new perspectives, but they do not necessarily disqualify earlier theories. Instead, they often complement earlier theories and enrich our understanding of the phenomenon.

3.2 Effects of Animation Features

Based on dynamic default theory, new object theory, and behavioral urgency theory, we identified three key animation features, i.e., motion, lagging, and looming, which each have unique characteristics at the lowest feature level (e.g., they can easily be formed into more complex animation features but cannot be easily decomposed into lower-level features). We define these features in the context of a predetermined online advertisement space (such as a rectangular area on a webpage) to provide more relevance and accuracy. According to dynamic default theory, these key animation features can gain attentional priority through the "default" attentional control setting when individuals have little motivation to set their attention on a particular salient feature. In other words, if individuals are given a specific search target that contains a salient feature, e.g., a green letter T, then their attentional control setting will be set to green and hence anything green in the visual field will attract their attention. But when no search target is given, individuals' attentional control setting will give priority to dynamic features by default. Hence, when developing the following hypotheses, we assume that online consumers are not given any specific search target (i.e., they are simply *browsing*), and thus have little motivation to set their attention to any particular salient feature, in which case the default attentional control setting prevails.

Motion. We define the animation feature of motion as a visual object that changes its physical location within a predetermined online ad space over time. According to dynamic default theory (Folk et al., 1992), dynamic objects, such as motion, garner attentional priority by default (attentional control setting). In particular, motion is unique in the way it can be registered effortlessly by the human visual system (James, 1950). For example, a natural way for us to draw a friend's attention is to wave our hands, which indicates the potential need for an immediate response (Franconeri & Simons, 2003). There is neuroanatomical evidence that specialized nerve cells are developed in our brain to detect motion (Goldstein, 1989). In the online environment, we anticipate that the application of a motion animation feature in an online ad will automatically attract online consumers' attention by also signaling behavioral urgency (Franconeri & Simons, 2003). Hence, we hypothesize:

H1: The motion animation feature increases online consumers' attention to animated ads.

Lagging. We define the animation feature of lagging based on the concept of abrupt onset in the attention literature. Abrupt onset is defined as the sudden appearance of a new object in an originally blank visual field (Jonides & Yantis, 1988). Physiological and psychophysical studies have suggested that the human visual system is particularly sensitive to abrupt stimulus onsets (Breitmeyer & Ganz, 1976; Breitmeyer & Julesz, 1975; Krumhansl, 1982; Todd & Van Gelder, 1979). New object theory (Hillstrom & Yantis, 1994; Yantis & Hillstrom, 1994) suggests that abrupt onsets receive priority by default because they indicate the presence of a new perceptual object. According to behavioral urgency theory, any new object in the visual field can indicate something that needs immediate attention (Franconeri & Simons, 2003). Applying the concept of abrupt onset in an online setting, we define the lagging animation feature as a visual object that is introduced after a time delay in a predetermined online ad space. An ad with a lagging animation feature seems likely to attract online consumers' attention, as it appears as a new object in the existing webpage; it can imply something that needs immediate attention (such as a warning message) and it is dynamic in nature. Hence, we hypothesize:

H2: The lagging animation feature increases online consumers' attention to animated ads.

Looming. We define the animation feature of looming as an increase in a visual object's size over time in a predetermined online ad space (Franconeri & Simons, 2003). Different from motion that involves the movement of the center location of an object without changing the size of the object, looming involves changing size with no movement of the center location of an object. As a dynamic event, a looming object will attract attention by default according to dynamic default theory (Folk et al., 1992). In addition, looming objects are more noticeable than receding objects (although they are both dynamic), because behavioral urgency theory argues that looming objects indicate behavioral urgency while receding objects do not (Franconeri & Simons, 2003). Compared with a person who is walking away from us, a person who is approaching us is more likely to attract our attention. In a previous study, looming images were found to elicit behavioral responses similar to a real approaching object (Wang & Frost, 1992). Also, Harrison, Rensink, and van de Panne (2004) conducted a study on cartoon animation depicting a walking child whose arms and legs change lengths over time. They found that looming is more noticeable than receding, suggesting the applicability of behavioral urgency theory to the online environment. Hence, we hypothesize:

H3: The looming animation feature increases online consumers' attention to animated ads.

Interaction. Since each of these three features has unique characteristics, it will be theoretically interesting and practically important to examine their interaction effects, as an existing animated ad may include more than one feature. For example, Bayles (2002) examined animated banner ads with words lying flat and then slowly standing upright, representing an interaction between motion and looming. Unfortunately, existing attention theories (Appendix Table B1) do not enable a direct prediction of the interaction effects. Theoretically, it depends on whether the combined features are more dynamic, more likely to form a new object, or signal more behavioral urgency than a single feature alone. Hence, each combination of features needs to be examined individually against each relevant theory. And, in this process, if relevant theories provide conflicting predictions, a null hypothesis may occur.

Applying the above reasoning to the context of our research, we analyze each pair of animation features to determine any possible interaction effect. First, we look at the effect of lagging (animation feature) when combined with motion (animation feature) or looming (animation feature). Visual salience studies (Abele & Fahle, 1995; Kastner, Nothdurft, & Pigarev, 1999; Nothdurft, 2000) suggest that combining two salient (visual) features results in increased salience and would presumably be better at attracting attention than each of the salient features alone. Following this argument, if we assume that combining lagging with either motion or looming makes the resulting animation more dynamic or more salient, then a positive interaction effect is expected (i.e., combining lagging with either motion or looming makes it better at attracting attention). However, such a combination does not make the ad more likely to appear as a new object, as lagging itself creates a new object in the visual field. Lagging is expected to induce online consumers to look at the object when it suddenly appears in a previously blank visual field. It is effective mostly because of the sudden appearance of a new object, not because of the property of such an object, i.e., whether it is moving or looming or static. Hence, we do not expect motion or looming to add to the possibility of creating a new object in the visual field. Similarly, motion and looming themselves both elicit strong signals of behavioral urgency. If the object is already moving or looming, then it will probably attract attention anyway, regardless of whether it is displayed sooner or later. Thus, the theories make conflicting predictions, leading to the following null hypotheses:

H4: The motion animation feature will NOT interact with the lagging animation feature, such that a motion animation feature will NOT be more effective in attracting online consumers' attention to animated ads when a lagging animation feature is also present.

H5: The looming animation feature will NOT interact with the lagging animation feature, such that a looming animation feature will NOT be more effective in attracting online consumers' attention to animated ads when a lagging animation feature is also present.

Next, we look at the interaction between motion and looming. Integrating motion and looming should increase the overall salience of the animated object. An object that is not only moving but also getting larger at the same time should be more salient than an object that is moving but staying the same size, or an object that is getting larger but staying in the same position. New object theory does not apply here because combining motion and looming does not make something more likely to appear as a new object. Finally, integrating motion and looming should also increase behavioral urgency. A moving object that is also coming forward (the visual effect of looming) sends a more urgent signal than an object that is simply moving but not coming forward. Thus, the relevant theories make consistent predictions, which lead to the following hypothesis:

H6: The motion animation feature interacts with the looming animation feature, such that a motion animation feature will be more effective in attracting online consumers' attention to animated ads when a looming animation feature is also present, as compared to when a looming animation feature is NOT present.

Lastly, no prior study has theorized or examined the combined effects of visual features in more than two dimensions. As there is inadequate theory to predict how three animation features will interact with each other, we do not formulate a three-way interaction effect.

3.3 Attention and Recall

With increased attention to the animated ad, we expect recall of the animated information to increase as well. Psychology scholars have suggested that attention affects the selection and processing of information (Mangun & Hillyard, 1991; Osman & Moore, 1993). According to cognitive information processing theory (Schunk, 1996), there are different stages of processing and storing information. Before individuals can recall any information by retrieving specific information from their memory, they need to have paid attention to the information in the first place. Whether they pay attention to the information will affect the subsequent processing and storage of information. Given the extensive information available on the web, in the context of this study, online consumers need to make choices regarding the information they will attend to before they can process and store the information for subsequent retrieval. Following prior researchers (e.g., Watt & Welch, 1983) who found that increased attention can affect further information processing and individuals' memory, we expect that allocation of attention to online ads will improve online consumers' memory of the online ads. If online consumers allocate more attention to online ads, then they will presumably spend more time processing/storing information about the ads, which should then lead to better recall of the online ads. Hence, we propose:

H7: The allocation of visual attention to online ads will improve recall of online ads.

3.4 Moderating Role of Task

We further explore an important boundary condition of the effect of animation features, i.e., task condition. In the online environment, there are typically two main task conditions, browsing versus searching. Following prior literature (Bodoff, 2006), we define browsing tasks as a task condition under which online consumers are simply visiting a website without a specific search target, and define searching tasks as a task condition under which online consumers have a specific target in mind when visiting a website.

We expect that the effects of animation will differ between these two task conditions because, under the browsing condition, subjects form no attentional control setting whereas, under the searching condition, they do. A core proposition of dynamic default theory (Folk et al., 1992) is that the attention allocation system can be "configured" or "set" to respond selectively to different salient features according to different behavioral goals or tasks. And, when individuals have little motivation to set their attention on a particular salient feature (e.g., in traditional attention research this would mean that the feature does not indicate the position of the search target; in the online environment, this would mean that a featured banner ad may not be relevant to online consumers' browsing tasks), dynamic features can gain attentional priority through the "default" attentional control setting. The above seven hypotheses are developed under the assumption of no specific search target assigned, which corresponds to browsing tasks defined earlier. In the context of searching tasks, however, a search target is typically given (e.g., searching for a particular piece of information on a webpage), in which case, features of the search target will form an attentional control setting that overrides the default attentional control setting. In other words, when the animated ad is irrelevant to the online consumers' search target, subjects will "set" their attention to respond only to features that could lead them to the search targets, weakening the effects of animation features. Extant research on online animation also shows that online consumers respond more strongly to animation under browsing conditions than under searching conditions (Cheung et al., 2017; Hong et al., 2007). Hence, we propose that:

H8: Task moderates the positive effects of animation on online consumers' attention to animated ads, such that the effects will be weaker when online consumers perform searching rather than browsing tasks.

4 Experiment 1: Research Methodology

We conducted the first experiment using student subjects from a public university in Hong Kong. We used a 2 (motion) ×2 (looming) ×2 (lagging) full factorial within-subject design, with eight animation conditions (Appendix Table D1). Subjects were shown a series of eight webpages, each containing a movie DVD ad and an article on robot dogs (robots designed to resemble dogs in appearance and behavior), with the animation features (or combination of animation features) applied to the DVD ad. Each subject was presented with eight different DVD ads and eight different articles on robot dogs. Appendix Figure E1 shows a sample webpage where all information is presented within the computer screen with no scrolling required. To minimize the influence of exogenous factors and improve the internal validity of the experiment, we carefully selected the materials to be used in the experiments through a series of pretests. Pretests using the same subject pool were conducted to select movie DVDs with similar levels of familiarity and ease of being recalled and articles on robot dogs with similar levels of interest (Appendix F).

According to Keppel and Wickens (2004), there are three principal advantages of a within-subject design versus a between-subject design: more effective use of subject resources, greater comparability of the conditions, and reduced error variance (controlling for subject differences). However, a major concern associated with within-subject design is the fact that the repeated observations must necessarily take place under somewhat different conditions, and some aspects of this difference, such as practice and fatigue, can affect the observation (Keppel & Wickens, 2004). To control for the influence of practice and fatigue, we used a Graeco-Latin square design (Fisher & Yates, 1957; Kirk, 2012), such that the order of the eight animation conditions, the eight DVDs, and the order in which the DVDs were presented, were systematically randomized (see Appendix Table G1). Therefore, each animation condition had an equal chance of being applied to each of the eight DVDs, each animation condition had an equal chance of being presented first, and each DVD had an equal chance of being presented first. While some fatigue and carryover effects may remain, any such incidental effects are already controlled for through use of a Graeco-Latin square design (Kirk, 2012).

4.1 Independent Variables

We created eight animation conditions using Adobe Flash for our experiment website (Appendix Table D1). We manipulated motion by moving a DVD ad in random directions in a predetermined ad space, i.e., a rectangular box in the upper-left corner of the webpage. Looming was manipulated by enlarging the size of a DVD ad within the ad space. Lagging was manipulated through the appearance of a DVD ad after a short time delay, consistent with the effect of an abrupt onset. To answer the call for higher relevance of IS research to practice (Rosemann & Vessey 2008), we designed animations that would be non-irritating and practical for websites to use. Pretests were conducted to ensure that the animations were non-irritating (Appendix F). To fulfill the requirements of the Graeco-Latin square design, we created a total of sixty-four animated ads with eight ads for each of the eight DVDs (Appendix Table G1).

4.2 Dependent Variables

We used two measures of eye tracking data as dependent variables. Eye tracking machines record gazepoints. A *gazepoint* is a location toward which the eyes are looking at a particular moment. Eye tracking machines typically record a person's gazepoints every 1-17 milliseconds. When a series of gaze points occurs near another in time and location, they are aggregated and assumed to represent a single *fixation*, a brief period of time lasting about 100 to 400 milliseconds, during which the eyes are held reasonably stable and steady at a location (Hornof & Halverson, 2002). These fixations are connected by *saccades*, or *scanpaths*, which are very rapid ballistic eye movements. Information processing only happens during fixations, but not during saccades (Rayner, 1998). Hence, we focused on fixation data as indicators of subjects' visual attention allocation. We used 100 milliseconds as the cutoff value to identify meaningful fixations, which is a commonly used value in the attention literature (e.g., Goldberg & Kotval, 1999). Appendix Figure E1 depicts a map of fixations connected by scanpaths from a randomly selected subject. We calculated two fixation measures: the total number of fixations on ads (*Fixation count*) and the total fixation time on ads (*Fixation time*). These two measures provided indications of whether the animation attracted subjects to look at the ads more frequently and for a longer duration on a webpage. We used recall of DVD ads (*Recall*) as an indicator of cognitive elaboration of animated content following the visual attention, which is a measure commonly adopted in prior literature (e.g., Bayles, 2002; Diao & Sundar, 2004; Rau et al., 2006).

4.3 Pilot Study and Experiment Procedure

A pilot study was conducted to evaluate the website design and the experiment procedure. Ten subjects drawn from the same sampling frame were recruited for the pilot study. After completing the experiment, the subjects were interviewed by the experimenter for their feedback on different aspects of the experiment. Based on their feedback, minor changes were made to refine the website design and the experiment procedure.

The subjects were recruited through the electronic notice board of the university's intranet. To encourage active participation in the experiment, monetary incentives were offered to the subjects. The eye tracking machine used in the experiment was the ASL 504 eye tracker. A standard protocol was used by the same experimenter for all subjects. Due to the usage of an eye tracker, only one subject could take part in the experiment at a time. To avoid any potential interaction among the subjects, we imposed temporal separations between subjects such that subjects were given no opportunity to talk to each other. Upon arrival at the experiment venue, the subject was directed to read a prepared script describing the experiment task. The experimenter then calibrated the eye tracking machine to track the subject's eye movements. Prior research has found that not everyone's eyes can be tracked with an eye tracking machine due to facial structure differences (Joachims et al., 2007). Subjects whose eyes could not be precisely calibrated were excluded from the experiment. In the end, we collected complete data from 45 subjects. After calibration, the subjects were asked to complete a filler task before starting the main experiment.

First, subjects were directed to the instruction webpage of the main experiment. After they clicked the "Next Page" button on the instruction webpage, they were directed to a webpage that contained a cover story. In the cover story, they were told that a brand-new website dedicated to robot dogs had been recently created. They were instructed to browse the website as they normally would when visiting a website for leisure purposes, and to read the articles at their own pace. Each subject proceeded through eight webpages—each contained a different article and a different ad under different animation conditions. The subjects' eye movements were tracked as they went through the eight webpages. At the end of the experiment, they were directed to an online questionnaire that collected data on their recall of the DVD ads, their demographic data (i.e., age, gender, and internet experience), and the control check questions.

4.4 Results

Of the 45 subjects, 25 were female and 20 were male. They were between 19 and 22 years old, with an average age of 20.42 years. The subjects had an average of 8.27 years of experience using the internet. The mean time it took for subjects to go through the webpages was 6.66 minutes (SD=2.12 minutes). While we controlled for the potential effects of fatigue with a Graeco-Latin square design, the short mean time reinforced our confidence that fatigue would not be a major issue. For control checks,[1] we tested whether the materials used in the main experiment were appropriate, including subjects' interest in the DVDs, subjects' interest in the articles, and subjects' familiarity with the DVDs. Our subjects' general levels of interest were 4.47 (SD=1.21) for the articles and 3.02 (SD=1.61) for the DVDs, both on a scale from 1 to 7. The medium levels of interest helped prevent ceiling effects or floor effects, where subjects might pay too much or too little attention to either the ads or the articles due to extreme levels of interest. A slightly lower than average interest in the DVDs also allowed us to have a more conservative test of the hypotheses, i.e., subjects would not be paying more attention to the ads because the DVDs were not of great interest to them. None of the subjects reported having any knowledge of the DVDs before the experiment. In summary, the experiment materials used in the study were appropriate for our purposes.

We proceeded to test whether the animation manipulations were non-intrusive to our subjects. The mean comprehension score of articles was 12.64 (SD=2.24) out of 20. A repeated measures MANOVA was performed to confirm that neither the animation features nor their interactions affected subjects' comprehension of the articles: motion (F=1.017, p=0.319), lagging (F=0.282, p=0.598), looming (F=1.228, p=0.274), the two-way interaction between motion and looming (F=0.011, p=0.916), the two-way interaction between motion and lagging (F=2.926, p=0.094), the two-way interaction between looming and lagging (F=0.052, p=0.821), and the three-way interaction between the three animation features (F=0.259, p=0.613). This finding indicates that our animation manipulation was not intrusive and allowed us to more conservatively test the hypotheses.

Table 1 presents the hypotheses testing results. We performed a repeated measures MANOVA on the sample, which showed significant results for motion (F=4.686, p=0.014), looming (F=4.118, p=0.023), the two-way interaction between looming and lagging (F=3.668, p=0.034), and the two-way interaction between motion and looming (F=4.337, p=0.019). Insignificant results were found for lagging (F=2.012, p=0.146), the two-way interaction between motion and lagging (F=0.957, p=0.392), and the three-way interaction between the three animation features (F=0.457, p=0.636). Following Huberty and Morris (1989), we then proceeded with tests of univariate ANOVAs. The results of univariate ANOVAs showed that motion significantly increased eye fixations on ads (F=8.382, p=0.006) and the time subjects spent viewing the ads (F=4.919, p=0.032), supporting H1. Consistent with the results of MANOVA, none of the ANOVA tests showed a significant result for lagging, thus rejecting H2. Looming significantly increased eye fixations on ads (F=4.298, p=0.044) and the time subjects spent viewing the ads (F=7.058, p=0.011), supporting H3.

[1] We did not perform a manipulation check of the animation features because the manipulation itself is evident from the design of the ads, while whether the subjects perceive them as what the researchers intended is out of the control of the researcher and, in fact, is exactly what the researcher wants to find out (O'Keefe, 2003). In our study, a manipulation check of the IVs would be asking the subjects whether they saw an ad that was moving, looming, or lagging. But no matter how they responded, the actual manipulation would still have been present. And since not all subjects looked at the same ad, such a measure would be unreliable.

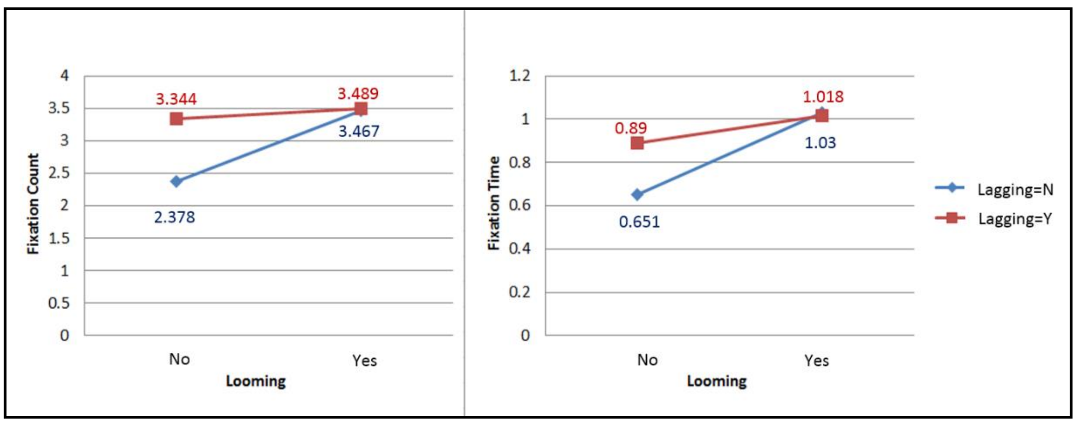
Table 1. Results of Experiment 1 and Experiment 3

			Experiment 1			Experiment 3		
			MANOVA	ANOVA		MANOVA	ANOVA	
Independent variables	**Dependent variables**	**Condition**	**F** *p*	**Mean**	**F** *p*	**F** *p*	**Mean**	**F** *p*
MO	**Fixation count**	no MO	4.686	2.828	8.382	3.265	2.180	6.432
		MO	*0.014**	3.511	*0.006***	*0.040**	3.670	*0.012**
	Fixation time	no MO		0.819	4.919		0.711	5.668
		MO		0.975	*0.032**		1.257	*0.018**
LA	**Fixation count**	no LA	2.012	2.922	4.032	0.715	2.800	0.181
		LA	*0.146*	3.417	*0.051*	*0.491*	3.050	*0.671*
	Fixation time	no LA		0.840	2.668		1.006	0.035
		LA		0.954	*0.109*		0.963	*0.851*
LO	**Fixation count**	no LO	4.118	2.861	4.298	3.142	2.200	6.092
		LO	*0.023**	3.478	*0.044**	*0.045**	3.650	*0.014**
	Fixation time	no LO		0.770	7.058		0.711	5.655
		LO		1.024	*0.011**		1.257	*0.018**
MO*LA	**Fixation count**	no MO + no LA	0.957	2.656	0.532	0.510	1.840	0.536
		no MO + LA	*0.392*	3.000	*0.470*	*0.601*	2.520	*0.465*
		MO + no LA		3.189			3.760	
		MO + LA		3.833			3.580	
	Fixation time	no MO + no LA		0.799	1.383		0.619	0.966
		no MO + LA		0.840	*0.246*		0.802	*0.327*
		MO + no LA		0.882			1.392	
		MO + LA		1.068			1.123	
LO*LA	**Fixation count**	no LO + no LA	3.668	2.378	7.325	1.236	2.000	0.065
		no LO + LA	*0.034**	3.344	*0.010***	*0.293*	2.400	*0.799*
		LO + no LA		3.467			3.600	
		LO + LA		3.489			3.700	
	Fixation time	no LO + no LA		0.651	5.173		0.796	0.304
		no LO + LA		0.890	*0.028**		0.626	*0.582*
		LO + no LA		1.030			1.215	
		LO + LA		1.018			1.299	
MO*LO	**Fixation count**	no MO + no LO	4.337	2.267	6.167	3.179	0.720	6.261
		no MO + LO	*0.019**	3.389	*0.017**	*0.044**	3.640	*0.013**
		MO + no LO		3.456			3.680	
		MO + LO		3.567			3.660	
	Fixation time	no MO + no LO		0.609	8.872		0.168	5.528
		no MO + LO		1.029	*0.005***		1.254	*0.020**
		MO + no LO		0.932			1.254	
		MO + LO		1.019			1.261	
MO*LA*LO	**Fixation count**	no MO + no LO + no LA	0.457	1.956	0.691	0.754	0.120	0.397
		no MO + no LO + LA	*0.636*	2.578	*0.410*	*0.472*	1.320	*0.530*
		no MO + LO + no LA		3.356			3.560	
		no MO + LO + LA		3.422			3.720	
		MO + no LO + no LA		2.800			3.880	
		MO + no LO + LA		4.111			3.480	
		MO + LO + no LA		3.578			3.640	
		MO + LO + LA		3.556			3.680	
	Fixation time	no MO + no LO + no LA		0.535	0.110		0.017	1.150
		no MO + no LO + LA		0.683	*0.741*		0.319	*0.285*
		no MO + LO + no LA		1.063			1.222	
		no MO + LO + LA		0.996			1.285	
		MO + no LO + no LA		0.767			1.575	
		MO + no LO + LA		1.097			0.934	
		MO + LO + no LA		0.998			1.209	
		MO + LO + LA		1.040			1.313	

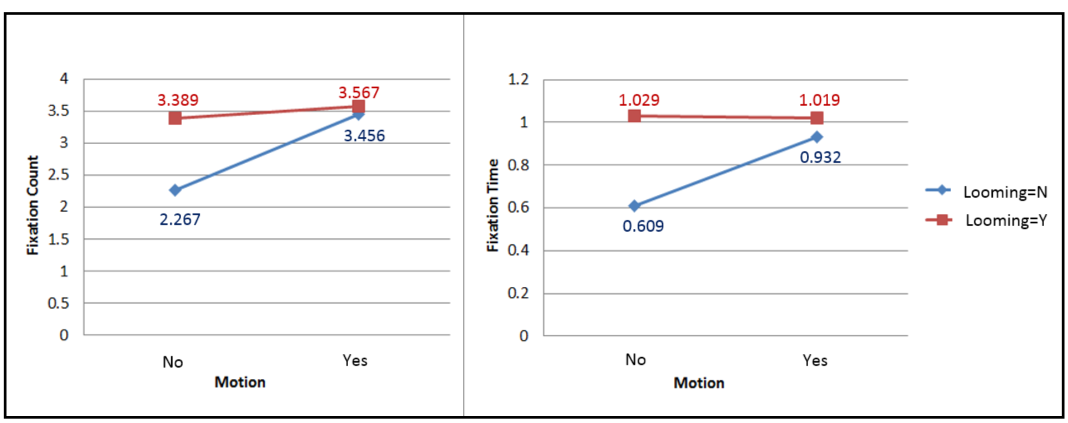
Note: * $p < 0.05$, ** $p < 0.01$. “MO” stands for Motion, “LO” stands for Looming, and “LA” stands for Lagging.

Consistent with the MANOVA results, the univariate ANOVAs results showed no significant interaction effects between motion and lagging for eye fixations on ads (*F*=0.532, *p*=0.470) and the time subjects spent viewing the ads (*F*=1.383, *p*=0.246). As stated in Cohen (1988, p. 18), proving a null hypothesis is not to conclude that there is no difference between two means. Instead, the affirmation of a null hypothesis is "rather that it is negligible, or trivial." That means the affirmation of a null hypothesis requires the assessment of the effect size. The effect size (Cohen's *f*) of the interaction is 0.21, indicating a small effect size (Cohen, 1988). Given the insignificant interaction effect and small effect size, we concluded that H4 is not rejected (Cohen, 1988; Khatri et al., 2006). However, there were significant interaction effects between looming and lagging for eye fixations on ads (*F*=7.325, *p*=0.010) and the time subjects spent viewing the ads (*F*=5.173, *p*=0.028), rejecting H5. The extent to which looming increased subjects' eye fixations and time spent on the ads was smaller when lagging was also present versus when lagging was absent (Figures 1a and 1b). In addition, significant interaction effects were found between motion and looming for eye fixations on ads (*F*=6.167, *p*=0.017) and the time subjects spent viewing the ads (*F*=8.872, *p*=0.005). A detailed examination of the data pattern (Figures 2a and 2b) showed that the effects of motion on eye fixations and time spent on the ads were dampened when looming was also present, which is the opposite effect of that hypothesized in H6.

To assess the effect of visual attention on recall in a repeated measures design, we used the generalized estimating equations (GEE) method (Zeger, Liang, & Albert, 1988). GEE was chosen because it can adjust for the correlations among observations from the same experiment subjects. We specified an unstructured correlation model, such that responses from the same subjects are allowed to freely correlate. The results revealed significant relationships between fixation time and ad recall (β=0.630, p<0.001) and between fixation count and ad recall (β=0.591, p<0.001), thus supporting H7.



Figures 1a and 1b. Interaction Effects Between Looming and Lagging on Fixation Count and Fixation Time (in Seconds) in Experiment 1



Figures 2a and 2b. Interaction Effects Between Motion and Looming on Fixation Count and Fixation Time (in Seconds) in Experiment 1

4.5 Discussion

We found that both motion and looming animation features are effective for attracting online consumers' gaze and attention to ads, supporting the utility of attention theories in the online environment. Specifically, dynamic default theory argues that dynamic objects garner attentional priority by default, which is supported by the significant effects for motion and looming (note that a looming object appears to be dynamic even though it remains in the same location). Similarly, the significance of looming in attracting attention provides support for behavioral urgency theory, as a looming object appears to be approaching and signals urgency to respond to it.

However, the lagging animation feature, which has the visual effect of an abrupt onset and was thus expected to generate attentional priority by default (Hillstrom & Yantis, 1994; Krumhansl, 1982; Todd & Van Gelder, 1979; Yantis & Hillstrom, 1994) was not effective in attracting online consumers' attention. A possible explanation is that online consumers are used to webpages that do not display all contents, such as graphics, at once due to download delays and network congestion, which are frequently cited problems of using the web (Taylor, Dennis, & Cummings, 2013). In this study, the subjects had an average of 8.27 years of internet experience and are probably used to download delays; they thus likely equated the abrupt onset with such delays. As a result, regardless of whether the delayed appearance is due to download delays or is deliberately manipulated by web designers, we suspect that experienced online consumers have learned to overcome the attention-attracting effect of abrupt onset.

Similarly, a moving ad with a time delay did not receive more attention from online consumers in our study. It appears that online consumers are so used to online delays that they do not pay more or less attention to delayed content regardless of whether it is moving or not. They likely just regard the delayed content as a typical viewing experience of webpages. However, we did find a significant interaction effect between lagging and looming, and between motion and looming. In both cases, adding another animation feature on top of an existing animation feature did not increase its effectiveness in attracting attention to the ad. When lagging or motion was not present, looming clearly increased the attention allocated to the ads. But when lagging or motion was already present, adding looming did not increase attention to the ad. Note that this finding is different from the phenomenon called "banner blindness," which describes subjects intentionally blocking an ad (Benway, 1998), especially if it moves or blinks. The reason that online consumers may develop "banner blindness" is because, over time, they are conditioned to expect that anything that is animated on a webpage is likely to be an ad. As a result, online consumers may intentionally block such animated ads, effectively blinding themselves to them. Although the concept of "banner blindness" was introduced over a decade ago, research findings are mixed (Appendix Table B1) and animated ads in various forms are still being used on websites today. In our study, "banner blindness" was not observed for a mild level of salience (such as motion or looming alone). Even when salience increased through combining two animation features (e.g., combining looming with motion), the attention level remained similar (i.e., it did not decrease as would have happened under "banner blindness").

Taken together, the results from Experiment 1 are in line with our expectations that the interaction effects of animation features need to be analyzed on a case-by-case basis, just as Koene and Zhaoping (2007) found that there are interactions between color features and orientation features, and between motion features and orientation features, but none between color features and motion features. In general, the results from tests of interaction effects do not support the visual salience literature, which argues that a more salient feature is definitely more likely to attract attention. Among the three two-way interaction effects of animation features, the interaction effect between motion and lagging was insignificant; and the other two interaction effects (i.e., between looming and lagging and between motion and looming) were significant, but in the opposite direction as that proposed by visual salience theory. We found that while visual salience can increase attention capture to a certain degree (e.g., by motion or by looming alone), after the visual salience reaches a certain threshold, any further increase in the salience will not increase attention capture. Based on Figures 1 and 2, combining one salient feature (e.g., motion) with another salient feature (e.g., looming) does not lead to increased attention. We label this phenomenon the "banner saturation" effect, meaning that online consumers are only willing to pay a certain amount of attention to animation features, no matter how salient they are. When "banner saturation" is reached, more salience will not further increase attention to the animated ads. Combining "banner saturation" from our study with "banner blindness" from prior literature would suggest a potential inverted U-shaped relationship between the salience of an animation feature (and the combination of animation features) and its effectiveness in attracting attention. While an initial increase in salience draws attention until it reaches the highest "saturation" point in the middle, too much salience may initiate the "banner blindness" process, causing attention to the animation to drop.

Apart from the significant relationships between certain animation features and visual attention, we also found significant relationships between the attention measures (i.e., fixation count and fixation duration) and recall of online ads. How frequently individuals look at the online ads and the duration of time that they spend viewing online ads can affect their memory of the online ads. According to cognitive information processing theory, whether individuals pay attention to the information will affect the subsequent processing and storage and retrieval of the information. In the case of animated ads, online consumers' attention must be drawn to the ads before they can process and store the information about the ads in their memory for subsequent retrieval. This finding provides empirical support for the conjecture in prior studies that attention determines what information will be encoded (Chun & Turk-Browne, 2007) and thus what encoded information can be subsequently retrieved.

5 Experiment 2: Searching Task

We conducted a second experiment to test the effects of animation in the context of searching tasks.

5.1 Experiment Subjects, Stimulus, and Procedure

We recruited a new group of 45 subjects, 24 female and 21 male, from the same sampling frame as Experiment 1. The subjects were between 18 and 22 years old, with an average age of 19.51 years. The subjects had an average of 8.22 years of experience using the internet. We used the same experiment materials used in Experiment 1, with appropriate changes in the cover story and instructions. In Experiment 2, subjects were asked to search for a specific phrase and count how many times it appeared across the eight articles. They were told to complete their searching tasks as quickly and as accurately as possible. A pretest was conducted and the above searching task was found to have an appropriate level of difficulty (Appendix H).

5.2 Manipulation and Control Checks

To assess whether the manipulation of task condition was successful, we checked for the effects of task on time spent in reading the articles. The manipulation check showed that the subjects spent significantly more time reading the articles in the browsing task than did the subjects in the searching task (F=8.284, p=0.005), and their comprehension of the articles was significantly better (F=32.956, p<0.001), thus confirming that our manipulations of the two tasks were successful. The results of conducting the control checks revealed that the experiment materials used in the study were appropriate and the animation manipulations were not intrusive to the subjects (Appendix H).

5.3 Results

As shown in Appendix Table H1, the MANOVA tests were not significant for motion (F=0.387, p=0.681), looming (F=1.493, p=0.236), lagging (F=1.535, p=0.227), the interaction between motion and looming (F=0.641, p=0.532), the interaction between motion and lagging (F=2.840, p=0.069), the interaction between looming and lagging (F=0.600, p=0.553), or the three-way interaction (F=0.137, p=0.872). Similarly, none of the ANOVA tests were significant. Consistent with our expectations, we observed weaker effects of animation on online consumers' attention when performing searching tasks as compared to browsing tasks, supporting H8.[2]

5.4 Discussion

Contrary to the results of the first experiment, which found certain significant main effects and interaction effects for the animation features, Experiment 2 revealed no significant main effects or interaction effects at all. This finding suggests that motion and looming animation features are only effective in attracting online consumers' attention when a specific attentional control setting has not been formed (i.e., under the browsing condition); however, they are not effective when a specific attentional control setting has been formed (i.e., under the searching condition).

6 Experiment 3: A More Realistic Website with Between-Subject Design

In order to provide evidence of external validity for Experiment 1, we examined the effects of the same set of animation features in a more realistic experiment website with a more complex design, which is both theoretically interesting and practically important. Theoretically, although neither of the three attention theories used in this study nor other attention theories identified in Appendix C formally incorporate complexity of the display, some researchers have noticed that the attention capture effect varies according to the number of items in the display (Franconeri & Simons, 2003; Hillstrom & Yantis,

[2] We also calculated the statistical power and effect size for the insignificant results. The statistical powers of the main effects and interaction effects are all below 0.530. The low powers of the insignificant tests were due to mainly small effect sizes (with most of them under 0.2). With these small effect sizes, the sample sizes required to achieve a statistical power of 0.80 for the main effects and the interaction effects would be from the 100s to over 1,000 (Cohen, 1988). While a significantly larger sample would be needed to confirm the findings, given the small effect sizes, it is unlikely that the validity of H8 would not hold (Cohen, 1988).

1994; Treisman, 1986; Treisman & Gelade, 1980). In general, response time increases with a higher number of items in the display, indicating a weaker attention-capturing effect of a feature when there are more distractors. But the increase is not linear nor consistent across features, in the sense that some features will lose their captive effect beyond a certain display size (Jonides & Yantis, 1988; Martin-Emerson & Kramer, 1997), while some features may remain strong or be less affected (Yantis & Hillstrom, 1994). Hence, we found it theoretically interesting to replicate the animation feature effects found in Experiment 1 in a more complex display with a higher number of distractors.

Such an effort could also help to validate the degree to which attention theories can be applied to real-life online settings. A major challenge in applying attention theories to the online setting is that these theories were developed and tested using very simple display settings (e.g., very simple targets and distractors in a single-colored background to maximize internal validity) (Duncan & Humphreys, 1989; Geissler, Zinkhan, & Watson, 2001; Nadkarni & Gupta, 2007; Treisman & Gelade, 1980), whereas real-life online settings are typically far more complex. The degree to which attention theories hold in real-life online settings is unclear. Some earlier research efforts on the online setting utilized highly simplified webpages (e.g., Hong et al., 2007; Zhang, 2000; 2006) to control for confounding effects and achieve higher internal validity. But there are also studies that built experiment websites based on existing websites or directly adapted webpages from existing websites (e.g., Bayles, 2002; Diao & Sundar, 2004; Hamborg et al., 2012; Josephson, 2005; Kuisma et al., 2010) for higher external validity. To strike a balance between the simple display settings in attention research and the much more complex webpages in practice, we used a relatively simple design in our experiment websites for Experiments 1 and 2. Having confirmed that attention theories can be applied to understand the effects of animation features in the online settings, we conducted another experiment using a more complex webpage design (which resembles a real commercial website) to verify our findings.

Meanwhile, psychology research suggests that the investigation of the same set of factors and tasks could possibly vary across a within-subject experiment and between-subject experiment from both experimental and statistical perspectives (Borsboom et al., 2009; Boy & Sumner, 2014). As highlighted by Boy and Sumner (2014), it might be difficult to avoid the implicit (and convenient) assumption that individual differences in the dependent variables in a between-subject experiment automatically reflect the same mechanisms studied by a within-subject manipulation, and vice versa. From a statistical perspective, the statistical differences that are driven by intra-individual variance in a within-subject experiment and inter-individual variance in a between-subject experiment could be different, even for the same manipulations and the same tasks (Borsboom et al., 2009). In Experiment 1, we used the within-subject design to control for the differences in individual characteristics by testing all treatment conditions against the same participant. In Experiment 3, we used a between-subject design, which has the advantage of avoiding the possible fatigue and carryover effects that may be present in a within-subject design. Investigating the same set of factors (animation features) in both a within-subject design and a between-subject design can lead to more stringent tests of theories (Boy & Sumner, 2014).

6.1 Experiment Subjects, Stimulus, and Procedure

We recruited a new group of 205 subjects from the same sampling frame as Experiments 1 and 2. Five subjects were removed after the control checks. Of the remaining 200 subjects, 117 were female and 83 were male. The average age of the subjects was 19.47 years old and they had an average of 9.79 years of experience using the internet. Experiment 3 adopted a full factorial design with three factors: motion, lagging, and looming. We applied the motion, lagging, and looming animation features to a credit card ad. Based on feedback from a focus group, the credit card ad was chosen for the banner ad because it was likely to be equally familiar and relevant to the subjects. The size of the credit card ad was the same as the size of the DVD ads in Experiments 1 and 2. Twenty-five subjects were assigned to each of the eight experiment conditions.

The website design of Experiment 3 was different from that of the previous experiments in the following ways. First, the overall design of the experiment website was more complex in Experiment 3.[3] To ensure ecological validity, we based the experiment website (Appendix Figure I1) on the design of a travel website in China that was unlikely to be familiar to the local Hong Kong residents comprising our sample. The experiment website contained multiple columns and displayed a combination of headlines, texts, and images. Second, the position of ads was moved from the upper-left to the bottom-right of the webpage. While Experiments 1 and 2 tested the effects of animation in a prime location on a

[3] We recruited 30 participants and asked them to compare the complexity between the website used in Experiment 1 and the one used in Experiment 3. All participants reported that the website used in Experiment 3 was more complex than the website used in Experiment 1.

webpage, Experiment 3 examined the effects of animation in a non-prime location on a webpage (Nielsen, 2006). Third, we used a credit card ad which was placed among other static ads on the same webpage. The credit card ad did not have any human faces, thus reducing any potential attention-attracting effect associated with a human face (Cyr et al., 2009). We used a hypothetical credit card to avoid subject bias. To avoid potential fatigue effects, the experiment website simply consisted of an instruction webpage, a webpage presenting the cover story, and a webpage showing the content and the ad.

After completing the calibration process for the eye tracker, the subjects were directed to the instruction webpage of the website. After reading the instructions, they clicked the "Next Page" button which brought them to the webpage containing the cover story. In the cover story, they were told that a brand-new website dedicated to lifestyle information had been recently established. They were instructed to browse the website as they would normally when visiting a website for leisure. After reading the cover story and clicking the "Next Page" button, they were then directed to a webpage containing texts, graphics, and a credit card ad. The subjects' eye movements were tracked while they browsed this webpage. Upon completing the browsing task and clicking the "Next Page" button, they were directed to an online questionnaire to collect data on their recall of the credit card ad, their demographic information, and the manipulation check question. The manipulation check question asked the subjects whether they noticed any animation applied to the credit card ad. To assess subjects' recall of the credit card ad, they were asked to identify the credit card that appeared in the experiment, from five hypothetical credit cards (one used in the experiment and four not used in the experiment).

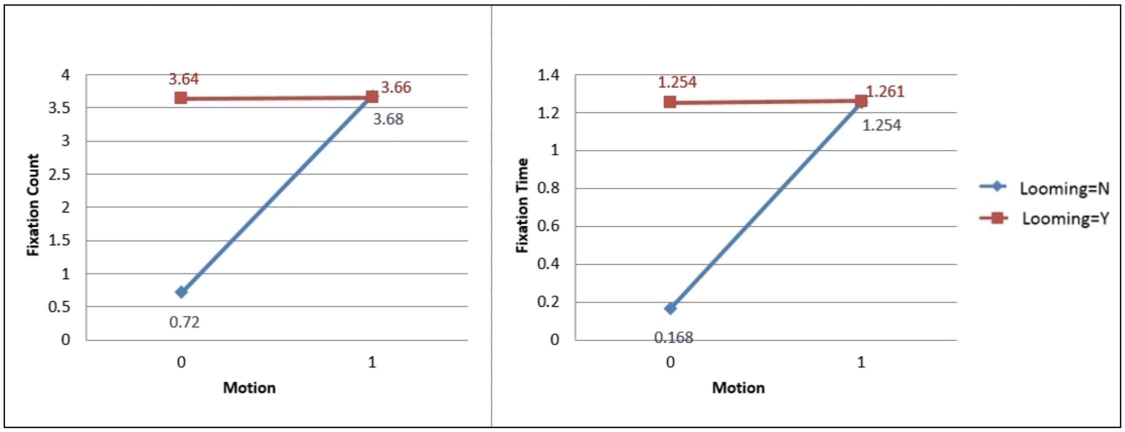
6.2 Control and Manipulation Checks

The control checks revealed that five subjects had previously visited the reference travel website based in China. These five subjects were removed from the subsequent data analysis, leaving 200 subjects. As the credit card was hypothetical, we did not need to check for subjects' familiarity with the credit card. Instead, we asked the subjects to indicate their preferences from among five hypothetical credit cards. The results showed that the credit card used in the experiment was the third choice among the 200 subjects. As discussed earlier, regardless of whether the subjects noticed the manipulation of animation features, it would not affect the manipulation itself. Nonetheless, we performed a univariate analysis of variance (ANOVA) and found that subjects reported higher percentages of noticing the animation when motion (F=26.032, p<0.001), lagging (F=4.578, p=0.034), or looming (F=7.828, p=0.006) were applied to the credit card ad.

6.3 Results

As shown in Table 1, a repeated measures MANOVA found significant results for motion (F=3.265, p=0.040), looming (F=3.142, p=0.045), and the two-way interaction between motion and looming (F=3.179, p=0.044). The results of univariate ANOVAs showed that motion significantly increased eye fixations on the ad (F=6.432, p=0.012) and the time subjects spent viewing the ad (F=5.668, p=0.018). Hence, H1 was again supported in Experiment 3. Looming significantly increased eye fixations on the ad (F=6.092, p=0.014) and the time subjects spent viewing the ad (F=5.655, p=0.018). Hence, H3 was also supported in Experiment 3. In addition, significant interaction effects were found between motion and looming in terms of eye fixations on the ad (F=6.261, p=0.013) and the time subjects spent viewing the ad (F=5.528, p=0.020). A detailed examination of the data pattern (Figures 3a and 3b) showed that the effect of motion is dampened when looming is also present, again opposite to the direction we proposed in H6, but consistent with Experiment 1.

On the other hand, there were insignificant results for lagging (F=0.715, p=0.491), the two-way interaction between motion and lagging (F=0.510, p=0.601), the two-way interaction between looming and lagging (F=1.236, p=0.293), and the three-way interaction between the three animation features (F=0.754, p=0.472). Consistent with the results of MANOVA, none of the ANOVA tests showed significant results for lagging; thus, as in Experiment 1, H2 was rejected. For the interaction effects, the results of univariate ANOVAs showed no significant interaction effects between motion and lagging on eye fixations on the ad (F=0.536, p=0.465) and the time subjects spent viewing the ad (F=0.966, p=0.327). The results of univariate ANOVAs also showed no significant interaction effects between looming and lagging on eye fixations on the ad (F=0.065, p=0.799) and the time subjects spent viewing the ad (F=0.304, p=0.582). The effect sizes (Cohen's f) for the interaction between motion and lagging and the interaction between looming and lagging were 0.07 and 0.11 respectively, indicating small effects (Cohen, 1988). Given the insignificant interaction effects and small effect sizes, H4 and H5 were not rejected in Experiment 3 (Cohen, 1988; Khatri et al., 2006). Finally, a logistic regression analysis revealed a significant relationship between eye fixations on the ad and ad recall (β=0.335, p<0.001) and the time subjects spent viewing the ad and ad recall (β=0.431, p<0.001), thus supporting H7.



Figures 3a and 3b. Interaction Effects Between Motion and Looming on Fixation Count and Fixation Time (in Seconds) in Experiment 3

6.4 Discussion

The results of Experiment 3 (which used a more realistic website and a between-subject design) are similar to those of Experiment 1, with only one exception. In both experiments, we found significant main effects for motion and looming animation, and a significant two-way interaction between motion and looming. However, the effect sizes for the significant effects were smaller in Experiment 3 than in Experiment 1, indicating a weaker effect of animation features, given the increased complexity of a website. This pattern is consistent with what has been observed in attention research, in the sense that when there are more distractors on display that compete for attention, the effect of salient features may decrease. We found that most of the effects of animation remained significant in a more realistic online setting but the effects were weaker.

One difference between the results of Experiments 1 and 3 is that the two-way interaction between looming and lagging was significant in Experiment 1 (i.e., the effect of looming on attention was dampened when lagging was present versus when lagging was not present) but not in Experiment 3 (i.e., the effect of looming on attention was not affected by the presence of lagging). There are two possible explanations for this finding. First, consistent with the earlier observation that the salience of animated features weakens in a more complex display, the interaction effect between looming and lagging was also reduced in Experiment 3. Following the previously identified "banner saturation" effect observed in Experiment 1, in a more complex display, the interaction between looming and lagging may not be strong enough to trigger "banner saturation" as it did in Experiment 1. Another possible explanation is related to the different location of the ad on the webpage in the two experiments. In Experiment 1, the animated ad was placed in a prime upper-left location, while in Experiment 3, the ad was placed in a non-prime location. It is common knowledge that contents in the prime upper-left location will have a better chance of being noticed than contents in the non-prime lower-right location (Shrestha & Lenz, 2007; Wilkinson & Payne, 2006). Even though the salience of the animation feature remains the same, the ad will naturally receive less attention when placed in a non-prime location and will therefore be less likely to trigger "banner saturation."

To summarize the results of Experiments 1 and 3 regarding the three interaction effects, we found that: (1) the interaction between lagging and motion was the weakest, evidenced by its relatively smaller effect size among the two-way interactions in both Experiment 1 and Experiment 3 (see Appendix Table J1), and it remained insignificant when moved to a non-prime location in Experiment 3; (2) the interaction between looming and motion was the strongest, triggering "banner saturation" in Experiment 1, and it remained significant when moved to a non-prime location in Experiment 3; and (3) the strength of the interaction between looming and lagging was somewhere in between the above two interactions, such that it was strong enough to trigger "banner saturation" in Experiment 1, but not strong enough to trigger "banner saturation" when moved to a non-prime location in a more complex environment in Experiment 3.

7 General Discussion

Table 2 presents a summary of all the hypotheses testing results for all three experiments. We next discuss the theoretical and practical implications based on this research, acknowledge the research limitations, and propose some future research avenues.

Table 2. Summary of Hypotheses Testing

Hypothesis	Experiment 1	Experiment 3	Experiment 2
H1: The motion animation feature increases online consumers' attention to animated ads.	Supported	Supported	
H2: The lagging animation feature increases online consumers' attention to animated ads.	Rejected	Rejected	
H3: The looming animation feature increases online consumers' attention to animated ads.	Supported	Supported	
H4: The motion animation feature will NOT interact with the lagging animation feature, such that a motion animation feature will NOT be more effective in attracting online consumers' attention to animated ads when a lagging animation feature is also present.	Not rejected	Not rejected	
H5: The looming animation feature will NOT interact with the lagging animation feature, such that a looming animation feature will NOT be more effective in attracting online consumers' attention to animated ads when a lagging animation feature is also present.	Rejected	Not rejected	
H6: The motion animation feature interacts with the looming animation feature, such that a motion animation feature will be more effective in attracting online consumers' attention to animated ads when a looming animation feature is also present, as compared to when a looming animation feature is NOT present.	Rejected	Rejected	
H7: Allocation of visual attention to online ads will improve recall of online ads.	Supported	Supported	
H8: Task moderates the positive effects of animation on online consumers' attention to animated ads, such that the effects will be weaker when online consumers perform searching rather than browsing tasks.			Supported

Note: H1 to H6 are developed and proposed based on the condition that online consumers have little motivation to set their attention to a particular salient feature and therefore the default attentional control setting prevails. In Experiment 2, however, participants were assigned with a searching task, such that they were motivated to form an attentional control setting with features of the search target, in which case the default attentional control setting is overridden.

7.1 Theoretical Implications

First, our study examined the utility of applying attention theories to the online environment using objective eye tracking data. Specifically, we used dynamic default theory, behavioral urgency theory, and new object theory to identify three key features of animation and predict their effects on attracting online consumers' attention. Our results show support for the first two theories in terms of predicting online consumers' eye movements in the online environment. However, the results do not reveal support for the lagging animation feature that is derived from new object theory. Our findings suggest that researchers should apply attention theories to the online environment with caution. Even if a theory is well established and has been tested in the offline environment, researchers should pay careful attention to the specific features of the online environment and online consumers' experience. While prior studies (e.g., Yantis & Jonides, 1984) investigating new object theory in the laboratory context have found that displaying visual objects following a time delay in the offline environment can capture individuals' attention, we found that displaying visual objects after a time delay is not effective in capturing online consumers' attention per our eye tracking data. This finding may be attributable to online consumers' experience with delayed contents in the online environment. Because of frequent download delays (Taylor et al., 2013), online consumers likely become used to delays in the appearance of certain webpage components and have learned to overcome the attention-capturing effect of abrupt onset in the online environment. Our results show that repeated exposure to a salient, dynamic, and behaviorally urgent feature may accelerate the otherwise extremely slow physiological change in attention capture, rendering such a feature no longer attention-significant, assuming task irrelevance of the featured object in the repeated exposures. In addition, our research indicates that when examining animated ads with multiple animation features, it is important to examine them on a case-by-case basis. The combined effect should be evaluated against each of the relevant attention theories. When the theories make conflicting predictions, null hypotheses may occur.

Second, our study reveals the significance of tasks when studying the effects of animation. Attention theories suggest that animation features are more likely to attract involuntary attention when no attentional control is set than when attentional control is set to a specific search target. Prior studies have examined the effects of animation under very different tasks, but only a few of them systematically varied the task and confirmed that the effects of animation vary across different tasks (Cheung et al., 2017; Hong et al., 2007; Jiang et al., 2009; Pagendarm & Schaumburg, 2001). Our research complements and extends prior studies by stipulating task as a boundary condition when applying attention theories. Specifically, online consumers performing browsing tasks are more vulnerable to the effects of animation as no attentional control setting is formed. On the other hand, online consumers performing searching tasks can be immune to the effects of animation as their attention has been set to respond selectively to task-relevant visual stimuli only. This can also explain the mixed findings in prior literature, e.g., why certain animation technologies work in some situations but not others. For example, while Bayles (2002) found that flashing and moving animation does not lead to better recall of the animated objects when individuals are assigned information search tasks, Lai, Hui, and Liu (2007) found that the use of blinking and moving animation leads to better recall of the animated objects when individuals are not assigned specific search targets. Our study provides explanations for these apparently conflicting findings by clarifying that the boundary condition of animation's effect is determined by the task condition.

Third, our study applied attention theories to a more realistic website environment. Previously, in the offline environment, attention theories are typically applied to simple displays using only symbols and letters. In our online settings, we show that eye movements are attracted to animation in a more complex visual environment with graphics and meaningful texts. We also found that the effect sizes of all the animation features are smaller in a more complex website environment than in a simpler website environment, indicating that the number of distractors or the amount of "noise" in the visual field weakens the effect of animation. By carefully testing attention theories in a real-life and more complex visual environment, we answer the call for greater relevance of IS research to practice (Rosemann & Vessey, 2008).

Fourth, our study is one of the first attempts to identify and isolate unique features of animation. Prior research that investigated animation using multiple animation features often overlooked its detailed features (e.g., Lang et al., 2002) or ignored the possible differential effects of different animation features (e.g., Bayles, 2002). As a result, it is difficult to understand the effects of animation (i.e., how each unique feature may contribute differently to the overall effect) or compare and consolidate findings across studies. The results of our research suggest that different animation features can have significant or insignificant effects on attracting online consumers' attention. By differentiating the key features of animation, this study allows researchers to see the effects of each animation feature and how they interact with each other to attract online consumers' attention. Our findings reveal two important conditions applicable to general attention theories. Each isolated animation feature should be identified by theories and tested under the relevant conditions in order for researchers to comprehend its effects. Absent such efforts, it will be difficult to advance attention theories or enrich the literature on web animation and website design. Our study also helps clarify the mixed findings in prior literature. For example, in both Lang et al. (2002) and Yoo and Kim (2005), the authors asked online consumers to perform browsing tasks and investigated the effects of animation on the recognition of ads. While animation was found to significantly improve the recognition of ads in Yoo and Kim (2005), it did not show any significant effect on the recognition of ads in Lang et al. (2002). The apparently inconsistent effects of animation may be explained by the different animated ads used in these two studies. In Lang et al. (2002), the animated ads were collected from websites without descriptions of the animation applied to the ads. In contrast, the animated ads in Yoo and Kim (2005)'s study are animated banner ads with three moving components looping at different intervals. As these two studies did not use animated ads with similar features, the main effects of animation would not necessarily be the same, as suggested by the results of our study.

Fifth, our study sheds light on the "banner blindness" phenomenon. If online consumers are indeed blind to online banners or animated ads, then websites should cease using banners/animated ads. The empirical results of Experiments 1 and 3 suggest that while a mild level of salience increases attention (such as motion or looming alone), the integration of two effective animation features may result in too much salience and initiate the "banner saturation" phenomenon. Please note that the animation features that we used in this study are relatively subtle features. Prior studies that found "banner blindness" effects typically used stronger animation features that are no longer adopted by most websites. Our results indicate that combining mild yet effective animation features may create "banner saturation" in the sense that online consumers are not willing to give more attention to them after a certain salience level is reached.

Sixth, this study answers the call by human-computer interaction researchers (e.g., Rau et al., 2007) for greater use of objective data to test hypotheses. Researchers are advocating the use of quantitative and objective data in addition to just perceptual data collected through questionnaires. The use of an eye tracking machine can help to reveal important information not available previously. Our eye tracking data provide empirical evidence that the use of animation increases online consumers' eye-fixation counts and the duration of eye fixations on online ads, which affects whether information is encoded into memory and the subsequent retrieval of information. Our findings complement prior studies that used recall as a surrogate measure of attention (Hong et al. 2004a; Hong, Thong, & Tam, 2004b; 2004c) by disclosing the underlying mechanism in using animation to affect online consumers' recall of animated objects. As a result, this study helps to establish the linkages between animation, attention, and recall. This study contributes to recent efforts by the IS and HCI communities to use eye tracking machines to investigate how online consumers view webpages of different designs and different components.

Finally, we replicated the within-subject Experiment 1 with a between-subject Experiment 3 using a more complex website design typical of real-life websites. Besides establishing a progressive application of attention theories from a simpler scenario to a more complex scenario, both experiments produce quite consistent results. The replication responds to the warning that "between-subjects variability can arise from an entirely different source from that driving within-subject effects" (Boy & Sumner, 2014, p. 1011). Our research also provides support for applying the Graeco-Latin square design in a within-subject experiment in the online context involving an eye tracking machine. The consistent results give us confidence that the Graeco-Latin square design is effective for balancing the order effect among treatments and reducing the impact of fatigue from multiple treatments, which are the two major concerns associated with within-subject design. By applying this experiment design method, researchers can realize much better utilization of subject resources in high-cost experiments, such as those involving an eye tracking machine.

7.2 Practical Implications

There are four practical implications that emerged from this study. First, motion and looming animation features induce eye movements, as predicted by attention theories (when online consumers do not have any predefined search target in mind). The experiment results showed that the application of either motion or looming animation features on online ads helps attract online consumers' gaze and attention, while the lagging animation feature does not. The results indicate that not every animation feature is effective in attracting online consumers' attention; hence, each animation feature needs to be examined separately. Interestingly, the human visual system may be better at adjusting to certain animation features than others. While motion and lagging animation features are both prevalent on the web, humans have successfully adjusted their visual attention systems in a way that prevents distraction by the lagging animation feature, but they are still distracted by the motion animation feature. More research is needed to understand how the human visual system may adjust differently to other animation features, which will help guide web designers' efforts in selecting appropriate animation features for their banner ads.

Second, animation features may interact with each other and the interaction effects of different pairs of animation features need to be examined and understood individually. We found a significant interaction effect between motion and looming animation features, such that they are weaker at attracting attention together than applied individually. Combining highly salient animation features may in fact "overdo" it and may not be more effective than a single animation feature. We also noticed a similar interaction effect between looming and lagging in Experiment 1. Although our study does not provide quantifiable results in terms of when an animation feature is too strong (and thus leads to a negative attention-attracting effect), it does provide general guidance to web designers that the integration of multiple animation features may not lead to desired outcomes. Designers should avoid combining multiple strong animation features on the same object in the hope of receiving more attention. In the long run, understanding the interaction effects among different animation features will help web designers select effective combinations of animation features in the same ad and avoid certain ineffective combinations of animation features.

Third, web designers should note that the same animation features may have very different effects on online consumers performing different online tasks. Online consumers who are focused on searching tasks on a website with the goal of accuracy and speed seem to be immune to the animation features used in this study. This may be partially attributable to the relatively subtle animation features examined in our study. With Google incorporating ad-blockers in its popular Chrome browser, it is critical to identify animation features and combinations that are effective and not annoying. In our study, motion and looming animation features were tested and confirmed to be effective and not intrusive, which not only allowed for a more conservative test of our hypotheses, but also contributes to the practical relevance of our findings.[4] Ideally, if web designers were able to predict whether an online consumer were engaged in browsing or searching tasks (e.g., checking the browser history), they would be able to provide the appropriate type of animated ad. Specifically, for online consumers who are browsing, subtle animation has a better chance of being effective, while for online consumers who are

[4] Note that the speed of motion and looming needs to be carefully controlled and tested to confirm non-intrusiveness.

searching, stronger animation is needed or, perhaps, no animated ad should be provided at all in order to avoid annoyance.

Fourth, web designers should also note that the complexity of the webpage design can affect the effectiveness of animated ads. Specifically, animation effects are expected to be weaker in a more complex design, so maybe a slightly stronger animation design is needed when the ad is placed on a complex webpage with many texts and images. Finally, it is not always advisable to pay premium advertising fees in order to place animated ads in a prime spot (such as the upper-left corner) on a webpage. The decision to place an animated ad in a prime location or a non-prime location should be determined by the characteristics of the animation. Placing an ad with strong animation in a prime spot may "overdo" it and lead to banner saturation or even banner blindness. Considering advertising effectiveness and fees, it may be more sensible to place an ad with relatively strong animation in a non-prime spot on a webpage.

7.3 Limitations and Future Research

The experiments used student subjects who are part of the younger population and are experienced internet users. Hence, the results of this study may be biased toward experienced internet users and/or young people. The accumulated internet experience of the experiment subjects may potentially explain the insignificant effect of the lagging animation feature in the experiments. However, considering that the physiological evolution of human visual perception happens very slowly, we believe that our findings based on attention theories likely apply to other populations as well. In addition, as prior research shows that animation has weaker effects for more experienced internet users (Dahlen, 2001; Hong et al., 2007), the more experienced sample allowed us to generate more conservative results. Another limitation of our study is that the animation features implemented are more prevalent among the top-ranked Chinese websites identified by Alexa. To investigate the possible effects of cultural differences, future research could investigate the animation features that are prevalent in the websites popular in Western countries. Further, while our results indicate a plausible inverted U-shaped relationship between the saliency of animation features and online consumers' attention capturing, we were not able to fully test this relationship in this paper. We urge researchers to further examine the shape of this relationship. Lastly, our paper provides a couple of guidelines for future research. First, it is critical for future studies on animation to report in detail how the animations they study are designed and implemented, allowing for the identification of the key features of each animation. This would enable other researchers to compare and integrate results across different studies and build cumulative knowledge on animation research. Second, it is important to specify the task conditions under which the research findings are applicable, as the same animation feature may have very different effects under different task conditions.

8 Conclusion

We examined both the direct and combinatorial effects of three animation features (i.e., motion, looming, and lagging) on capturing online consumers' attention in different online tasks using objective eye tracking data. While motion and looming are effective for capturing online consumers' attention, lagging is not as effective. The effect of the motion animation feature is dampened when the looming animation feature is also present. We also found a positive relationship between online consumers' attention and their recall performance. Furthermore, the effects of these animation features are stronger when online consumers are browsing websites than when they are searching for a particular target object. Also, we found the effects of the animation features to be weaker on a more complex webpage than on a simpler webpage. This research helps explain the mixed findings found in the prior literature by showing that the effects of animation in the online environment are contingent on multiple factors, including the specific animation feature, task condition, and complexity of the webpage.

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Appendix A

Screenshots of Three Alexa Top 50 Websites

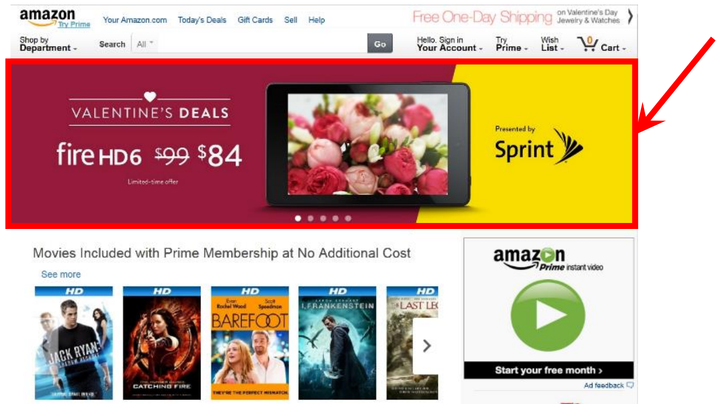

Figure A1a. Amazon.com: The Banner Switches from One Ad to Another

Figure A1b. Tmall.com: The Male Model and the Words in the Middle Ad Change in Size and Shake.[5]

Figure A1c. Weibo.com: The Upper Ad Has Moving Objects and The Right-Hand-Side Ad Has Lagging Objects[6]

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[5] Tmall.com is a popular business-to-consumer (B2C) online retailer. It is a spin-off of Taobao and is operated by Alibaba Group.

[6] Sina Weibo is a Chinese microblogging website with 550 million monthly active users (as of March 2020, see http://ir.weibo.com/news-releases/news-release-details/weibo-reports-first-quarter-2020-unaudited-financial-results).

Appendix B

Table B1. Summary of Literature Review

Literature	Number of Subjects	Task	Animation Features				Main Dependent Variables		Main Findings
			Description	Motion	Looming	Lagging	Objective data	Self-Reported data	
Bayles (2002)	66	Searching	Animated banner ads with flashing, enlarging, and moving texts (e.g., special effects with words lying flat and slowly standing upright)	X	X	X		Recall; aided recall (recognition)	Animation does not increase recall or recognition.
Benway & Lane (1998) (Experiment 2)	72	Searching	Animated banners with moving text	X	-	-	Search time	Recall	Animation does not lead to better recall of the banner.
Burke et al. (2005) (Study 1)	12	Searching	Flashing text banner (text appear in the left and right alternatively, without any motion); and animated banners collected from websites	?	?	X	Search time; accuracy	Perceived workload; impression of performance	Flashing text increases perceived workload (frustration and mental demand); animation does not affect searching performance.
Burke et al. (2005) (Study 2) / Burke et al. (2004)	24	Searching	Animated banners collected from websites	?	?	X	Search time; accuracy; eye-tracking data (number of banners viewed)	Aided recall (Recognition)	Animation has stronger effects on searching performance when the searching task is simpler and less demanding. Animation leads to poorer recognition when correcting for participants' guessing strategies. Animated banners did not affect the number of banners viewed.
Cheung et al. (2017)	60	Searching and browsing	Water waves are moving in the background of the product title on a retail website	X	-	-	Eye-tracking data (number of fixations; duration of fixations)		Animation increases the number of fixations and duration of fixations to all products on the retail website. The effect of animation is stronger for browsing tasks than for searching tasks.
Cho (2003)	751	Browsing	Animated banner ads with three frames one after the other	?	?	?	Click-through rate		Animation increases click-through rate, but only to people with low levels of product involvement.
Diao & Sundar (2004)	60	Browsing	Pop-up ads displayed after 15 seconds of delay; animated banner ads collected from websites (containing moving and flashing images or texts)	X	?	X	Orienting responses	Recall; aided recall (recognition)	Pop-up ads elicit orienting responses (indexed by heart rate) while animated banner ads do not. Animated pop-up ads further increase orienting responses. Animation has no effect on recall or recognition.

									Pop-up ads have lower recognition but higher recall than banner ads.
Diaper & Waelend (2000)	12	Searching	Animated graphics collected from websites (e.g., motion)	X	?	?	Search time	Immediate perceived complexity	Animated graphics do not affect search time.
Dreze & Hussherr (2003) (Study 2)	807	Searching	Animated banner ads without specific description	?	?	?		Recall; brand recognition; brand awareness	Animation has no effect on recall, brand recognition, or brand awareness.
Gao et al. (2004)	128	Searching	Pop-up ads displayed after 30 seconds or 3 minutes; animated banner ads continuously running	?	?	X		Perceived irritation; attitude toward the website	The continuous animated banner ads increase perceived irritation and negatively affect attitude toward the website.
Hamborg et al. (2012)	54	Searching	Certain letters in a banner ad rotates in a sequence from left to right	X	-	-	Eye-tracking data (number of fixations; duration of fixations)	Attractiveness of the ad	Animation increases number of fixations but not duration of fixations. Animation improves ad recall.
Harrison et al. (2004)	12	Count and detect changes	Animated motion with a walking child whose arms and legs change lengths over time	X	X	-		Count of changes, and direction of length changes	Looming is more noticeable than shrinking. Unrelated tasks distract subjects from the main task.
Hong et al. (2004a)	186	Searching	Flashing text applied to products on a retail website	-	-	X	Response time	Aided recall (Recognition); focused attention; attitude toward the website	Animation attracts attention but does not increase recall. Moreover, it reduces recall of other items on webpages, and negatively affects focused attention and attitude toward the website.
Hong et al. (2007)	230	Searching and browsing	Flashing text applied to products on a retail website	-	-	X	Clicking behavior; purchasing behavior	Focused attention; attitude toward the website	Animation attracts attention and increases chance of purchase under browsing condition. Stronger negative effects of animation on task performance and perceptions for browsing tasks than for searching tasks.
Jiang et al. (2009)	292	Searching and browsing	Animated ads that move continuously or move suddenly from a previously static state; animated ads that increase or decrease in size	X	X	-		Aided recall (Recognition)	Animation significantly improves ad recognition. Animated ads that increase in size lead to better ad recognition than animated ads that decrease in size.
Josephson (2005)	32	Browsing	Banner ads with moving image	X	?	?	Eye-tracking data (number of fixations; duration of fixations)		Animation does not have a significant effect on the number of fixations and total fixation durations but only has a marginally significant effect on the

									number of different times subjects looked at the banner ads.
Kuisma et al. (2010)	28	Browsing	Banner ads selected from TeliaSonera's banner archive	?	?	?	Eye-tracking data (percentage of fixations)	Aided recall (Recognition)	Animation does not have a significant main effect on the percentage of fixations. Animated banner ads are associated with better recall.
Lai et al. (2007)	80	Browsing	Animated website with blinking, motion, gradual fade-in effects	X	-	X		Recall; attitude toward the products; hedonic and utilitarian perceptions	Animated objects have better recall than nonanimated objects. Animation improves the perceived hedonic and utilitarian values of the products.
Lai et al. (2009)	80	Browsing	Animated website with blinking, motion, gradual fade-in effects	X	-	X		Recall; attitude toward the products; hedonic and utilitarian perceptions	Animated objects have better recall than nonanimated objects. Animation improves the perceived hedonic and utilitarian values of the products.
Lang et al. (2002) (Study 3)	35	Browsing	Animated banner ads collected from websites	?	?	?	Orienting responses	Recall; aided recall (recognition)	Animation elicits orienting responses (indexed by heart rate). Animation has no effect on recognition but increases recall of images (but not texts).
Lee & Ahn (2012)	118	Browsing	Animated ads with switching scenes	?	?	?	Eye-tracking data (number of fixations; duration of fixations)	Aided recall (recognition); brand attitude	Animation leads to fewer fixations and a shorter duration of fixations. Duration of fixations increase recall but decrease brand attitude.
Li & Bukovac (1999)	224	Searching and browsing	Animated banner ads with moving objects	X	-	-	Click-through rate; response time	Recall	Animation results in faster response and better recall. The effects do not differ between searching and browsing tasks.
Pagendarm & Schaumburg (2001)	32	Searching and browsing	Animated graphical banner ads	?	?	?		Recall; aided recall (recognition)	The recall of animated banner ads is higher under the browsing condition than under the searching condition.
Phillips & Lee (2005) (Study 2)	148	Browsing	Animated animal spokes-characters with movements	X	?	?		Attitude toward character; attitude toward website; social presence; perceived entertainment	Animated animal spokes-characters lead to favorable attitudes toward the animal characters and the websites. Subjects report greater perceived entertainment with the presence of animated spokes-characters.
Rau et al. (2006)	72	Searching	Flash banners with audio	?	?	?		Recall; aided recall (recognition); attitude; purchase intention	Animation (flash banner) leads to better ad recognition than that of static banners. Flash banners do not have a significant effect on ad recall, ad attitude, brand attitude, or purchase intention.

Rau et al. (2007) (Study 2)	70	Searching	Floating or non-floating animation frames with animated content inside	X	X	?	Search time; accuracy	Aided recall (recognition); satisfaction	Animation led to longer search time and poorer user satisfaction. No significant effect between floating and non-floating animation frames.
Sundar & Kalyanaraman (2004)	47	Browsing	Animated ads with either text or images that move or flash during or after loading; animation speed varies (faster vs. slower)	X	?	X	Physiological arousal	Recall; aided recall (recognition); behavioral intention; website appeal and usefulness	Fast animation ads led to higher levels of physiological arousal (measured by the skin conductance level) than slow animation ads. Speed of animation did not have significant effect on ad recall or recognition.
Sundar & Kim (2005)	48	Browsing	Animated ads with either text or objects that move or flash during or after loading	X	?	X		Attitude toward the ads; attitude toward the products	Animated ads lead to favorable attitude toward the ads but poorer attitude toward the products.
Yoo et al. (2004)	50	Browsing	Animated banner ads with three moving advertising cues looping one time each 10 seconds	X	?	?		Self-reported attention; recall; aided recall (recognition); attitude toward ad; click-through intention	Animated banner ads attract attention, and lead to more favorable attitude toward the ads and higher click-through intention. Animated banner ads lead to better recall but not recognition.
Yoo & Kim (2005)	195	Browsing	Animated banner ads with three moving components looping at different intervals	X	?	?		Self-reported attention; recall; aided recall (recognition); attitudes toward ad; emotional responses; cognitive responses	Animation interval does not affect recall of ads but does increase recognition and attitude toward ads. Subjects report more attention to high animation intervals.
Zhang (2000)	24	Searching	Animated strings and images with changing sizes and movement	X	X	X	Search time; accuracy		Animation negatively affects main task performance and affects simple tasks more than it affects difficult tasks.
Zhang (2006) (Study 2)	25	Searching	Animated images appearing at different times during the course of the task	?	?	X	Search time; accuracy	Interference perception; attitude toward animation	Animation appearing in the middle or toward the end of the task has larger negative impact than animation appearing at the beginning of the task.
Zhang (2006) (Study 3)	121	Searching	Same as Study 2, but compared the results of four replicated studies conducted over 5 years.	?	?	X	Search time; accuracy	Interference perception; attitude toward animation	Animation effects remain similar with increased internet experience. Animation has negative impact on task performance except for when it appears at the beginning of the task on the right side of the screen.

Note: "X" means existence of a particular animation feature; "-" means non-existence of a particular animation feature; "?" means insufficient information to determine the type of animation feature

Appendix C

Table C1. Attention Theories and Models

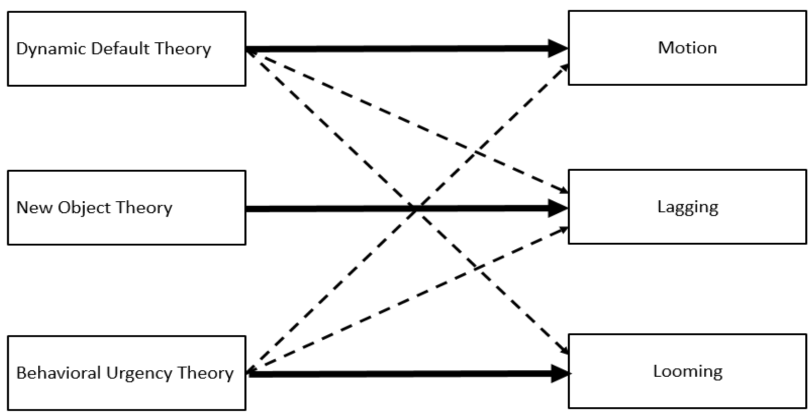
Theories	Description of the theories	Salient features	Reference
Feature integration theory	A two-stage model where a pre-attentive parallel stage of processing is followed by a more sophisticated serial stage of processing. Only basic features can support parallel search, whereas all other stimuli require a serial search.	Any basic features, such as color, size, and orientation, can be processed pre-attentively in the parallel stage.	Treisman & Gelade (1980); Treisman (1986)
Distinctiveness theory	If certain attributes of a stimulus make it different from all other elements in the visual domain, i.e., produce a distinctive effect, the stimulus is in an advantageous position to attract and hold viewers' attention.	Any stimulus with distinctive features such as color or orientation.	Gati & Tversky (1987); Nairne et al. (1997)
Similarity-based theory	Target detection shall be efficient to the extent that the target differs from the background in some dimension and the background is relatively homogeneous in that dimension.	Any stimulus with salient features, such as orientation and color, from the background.	Duncan & Humphreys (1989)
Visual saliency theory	An object may attract attention merely by its saliency, regardless of whether it is related to the search task.	Any stimulus with salient features, such as orientation, color, luminance, motion, and depth.	Nothdurft (1993a)
Dynamic default theory	Individuals form attentional control settings to respond faster to particular salient features that are set to be task relevant. When there is little motivation to configure the setting for a particular salient feature, any dynamic event garners attentional priority by default.	Any dynamic event such as abrupt onsets, or strong luminance changes.	Folk et al. (1992)
Local feature contrast theory	It's the local feature contrast, not merely the presence of unique features that facilitates the detection of targets.	Any stimulus with salient features, such as orientation and color, from its immediate neighbors.	Nothdurft (1993b)
Guided search model	An item attracts attention during visual search if it matches the target, or if it differs from other items in the display within a specific dimension.	Any stimulus with salient features, such as orientation, color, and motion.	Cave & Wolfe (1990)
New object theory	Motion, or any other attribute, only captures attention in a stimulus-driven fashion when it creates a new perceptual object.	Any stimulus that creates a new object file, such as abrupt onset or some specific types of motion.	Hillstrom & Yantis (1994); Yantis & Hillstrom (1994)
Behavioral urgency theory	Stimuli that signal potentially behaviorally urgent objects (events) are more likely to receive attentional priority.	Any stimulus that signals behaviorally urgent objects (events), such as looming.	Franconeri & Simons (2003)

Salience is defined as local contrast in any of the basic visual feature dimensions[7] (Nothdurft, 1993a), e.g., motion (Dick, Ullman, & Sagi, 1987; McLeod, Driver, & Crisp, 1988), orientation (Moraglia, 1989), size (Treisman & Gormican, 1988), and color (Treisman & Souther, 1985). Multiple attempts have been made by attention theorists to understand why certain salient features are better at attracting attention than others. They argue that a salient feature may attract attention because of its dynamics (Folk et al., 1992), its distinctiveness (Gati & Tversky, 1987; Nairne et al., 1997), contrast with immediate neighbors (Duncan & Humphreys, 1989; Nothdurft, 1993a), pre-attentive processibility (Treisman & Gelade, 1980; Treisman, 1986), etc. However, many of them focus on static features, such

[7] The term "feature" refers to a particular property within a dimension, e.g., green is a feature within the dimension of color, and vertical is a feature within the dimension of orientation.

as color and orientation (e.g., feature integration theory (Treisman & Gelade, 1980; Treisman, 1986), similarity-based theory (Duncan & Humphreys, 1989), and local feature contrast theory (Nothdurft, 1993b)), or do not differentiate between static features and dynamic features (e.g., distinctiveness theory (Gati & Tversky, 1987; Nairne et al., 1997), guided search model (Cave & Wolfe, 1990), and visual saliency theory (Nothdurft, 1993a)).

Hence, we chose three theories that are most relevant and directly applicable to the understanding of how dynamic features (i.e., animation) can attract online users' attention. The three theories are *dynamic default theory* (Folk et al., 1992), *new object theory* (Hillstrom & Yantis, 1994), and *behavioral urgency theory* (Franconeri & Simons, 2003). The figure below illustrates the relationships between the three theories and the corresponding animation features. Specifically, dynamic default theory plays a central role in explaining the effect of the motion animation feature and a peripheral role in explaining the specific effects of lagging and looming animation features, as motion is clearly dynamic, while lagging and looming can also be considered as dynamic events. New object theory directly explains the effect of the lagging animation feature, as a lagging feature will make a new object appear in the visual field. Lastly, behavioral urgency theory plays a central role in explaining the specific effect of the looming animation feature, as the theory was originally developed to explain why looming objects attracts more attention than receding features, even though both are dynamic in nature. Meanwhile, this theory also plays a peripheral role in explaining the specific effects of motion and lagging animation features, as anything that moves or suddenly appears in one's visual field may signal behavioral urgency to respond as well.



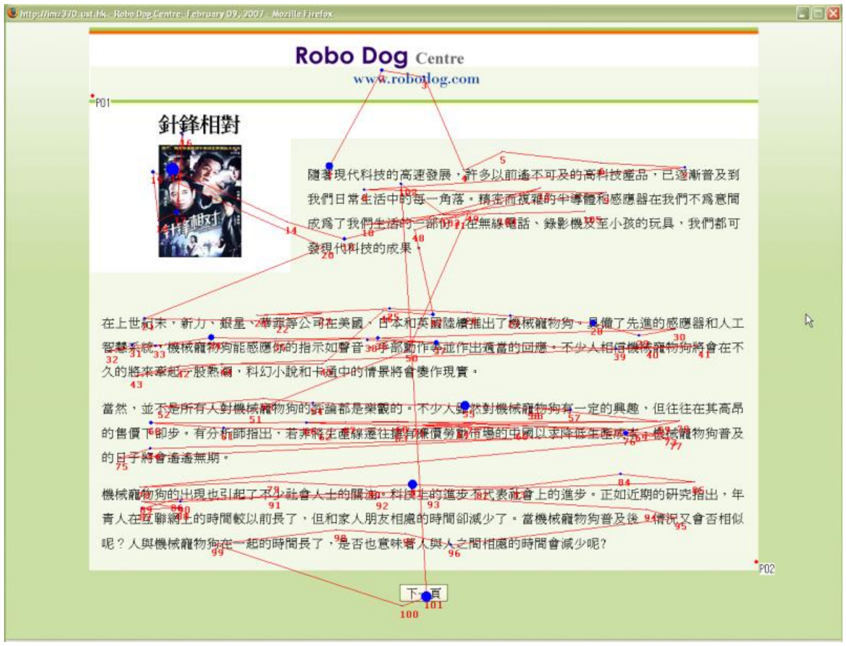
There are challenges in applying the theories directly to the online setting. First, the display of a webpage is typically much more complex than the display setting under which attention theories were previously tested (Geissler et al., 2001; Nadkarni & Gupta, 2007). While only text letters or symbols were used in prior research, a webpage is usually composed of graphics and meaningful text. So, the degree to which the theories will hold in a much more complex visual field is yet to be determined. Second, modern animation technologies, such as Adobe Flash, enable the creation of very complex animated stimulus, as compared to feature singletons (i.e., such as a tilted bar among vertical ones) adopted in psychology research. An animated ad may include multiple salient features (e.g., moving and looming at the same time), but prior animation studies (e.g., Hong et al., 2004a) are limited in terms of examining stimuli combining multiple salient features. Third, in attention research, the accuracy in identifying the target objects and the corresponding response time are typically used as indicators of attention capturing, while in the online environment, researchers are more interested in online users' responses to and fixations on the visual stimulus themselves. Lastly, tasks performed online (e.g., reading an article or searching for a product) are often much more complex than tasks performed in prior attention research (e.g., searching for a tilted bar), so the degree to which the theories will hold in the online task environment is yet to be ascertained. Despite the challenges, these three attention theories provide us with the foundation to identify three key animation features. Considering that the physiological evolution of humans' visual perceptions happens very slowly and that prior IS research using attention theories has demonstrated reasonable success, we believe these theories provide useful guidance in the selection of animation features, as well as theorizing their effects in an online environment.

Appendix D

Table D1. Eight Animation Conditions

Animation Conditions	Motion	Looming	Lagging	Description
A1	0	0	0	*Baseline condition*: Static ad, same size, appears together with article.
A2	0	0	1	Static ad, same size, appears five seconds after the article.
A3	1	0	0	Same size ad, appears together with article, starts random movement after loading.
A4	1	0	1	Same size ad, appears five seconds after the article, starts random movement after loading.
A5	0	1	0	Looming ad, appears together with the article, becomes static after looming to full size.
A6	0	1	1	Looming ad, appears five seconds after the article, becomes static after looming to full size.
A7	1	1	0	Looming ad, appears together with the article, starts random movement after looming to full size.
A8	1	1	1	Looming ad, appears five seconds after the article, starts random movement after looming to full size.

Appendix E



Note: Dots represent fixations with diameters indicating the length of the fixations; lines represent scanpaths.

Figure E1. Sample Webpage Superimposed with a Subject's Scanpath

Appendix F

Pretests in Experiment 1

The first pretest was conducted to select eight products that were suitable to be used in the ads. The products were selected with the following considerations. First, the products must be from the same category, so that they were comparable in terms of visual presentation and subjects' involvement level. Second, the products should have similar levels of familiarity to the subjects, so that subjects would not pay more attention to a particular product in the ads because they were more familiar with it. Third, the names of the products had to be carefully selected to ensure that a particular ad would not be more easily remembered because of its name. Although randomization through Graeco-Latin square design would balance any possible effects of product names, this additional consideration should help to further control for any variance due to the names of the products. We chose movie DVDs as the advertised products for the main experiment as DVDs have the same size and shape regardless of their film titles. We selected 24 movie DVDs that were directed by unknown directors in China. As these movie DVDs are not popular in Hong Kong, especially with the younger generation, our subjects, local Hong Kong students, would not be expected to be familiar with them. In addition, we controlled for color scheme by selecting DVDs with similar color schemes on the covers (e.g., all with dark colors). A pretest was conducted with 30 subjects from the same subject pool. Each subject watched a Powerpoint slide show presenting the 24 DVDs in random order. Each DVD was displayed for five seconds. After the slide show, subjects were given a list of 24 DVDs and asked to tick those that they have seen in the Powerpoint slide show or they had heard of. We performed statistical tests to select eight DVDs that had similar levels of recall performance by the subjects, and the film titles were unfamiliar to all of them.

In the second pretest, we carefully designed the content of the articles to ensure that they were on the same topic and of similar lengths (Chan & Lee, 2005). A focus group drawn from the same subject pool discussed a number of selected topics before identifying a topic that was of moderate interest to them. This step was needed to ensure that the subjects in the experiments would not be overly interested or bored by the articles. Robot dogs were selected as a topic of moderate interest to our subjects. Another reason is that the eight selected DVDs are totally unrelated to the robot dogs. We prepared eight articles that were of similar lengths and focused on different aspects of robot dogs (e.g., robot dogs as robot pets or military robots). To make sure that the eight articles' degree of interest for the subject pool is more or less the same, the eight articles were then reviewed by another focus group. Two rounds of revisions were conducted before we finalized the articles.

Apart from pretesting the experiment materials, we pretested the manipulations of animation features to ensure that the animation features were non-irritating. Motion was manipulated by moving the DVD ads in random directions in the predetermined ad space, i.e., a rectangular box at the upper left corner of the webpage. As faster animation would elicit significantly higher arousal than slow animation (Sundar & Kalyanaraman, 2004), we pre-tested the speed of motion to ensure that it was non-irritating to our subjects. Looming was manipulated by enlarging the size of the DVD ads. Expanding patterns were found to simulate a looming object (Franconeri & Simons, 2003) and elicit similar behavioral responses as a real approaching object (Wang & Frost, 1992). We pre-tested different speeds for looming before settling on a speed that was perceived by the subjects to be comfortable (not too fast and not too slow). Lagging was manipulated by the appearance of a DVD ad after a short time delay, consistent with the effect of an abrupt onset. While using non-irritating manipulations may reduce the chances of finding significant effects, they allowed for a more conservative test of our hypotheses.

Appendix G

Table G1. Graeco-Latin Square Design of Experiments 1 and 2

	C1	C2	C3	C4	C5	C6	C7	C8
Subject 1	A1M1	A2M2	A3M3	A4M4	A5M5	A6M6	A7M7	A8M8
Subject 2	A2M5	A1M6	A4M7	A3M8	A6M1	A5M2	A8M3	A7M4
Subject 3	A3M2	A4M1	A1M4	A2M3	A7M6	A8M5	A5M8	A6M7
Subject 4	A4M6	A3M5	A2M8	A1M7	A8M2	A7M1	A6M4	A5M3
Subject 5	A5M7	A6M8	A7M5	A8M6	A1M3	A2M4	A3M1	A4M2
Subject 6	A6M3	A5M4	A8M1	A7M2	A2M7	A1M8	A4M5	A3M6
Subject 7	A7M8	A8M7	A5M6	A6M5	A3M4	A4M3	A1M2	A2M1
Subject 8	A8M4	A7M3	A6M2	A5M1	A4M8	A3M7	A2M6	A1M5

Note:
"C" stands for the order of the articles. There were a total of eight different but related articles.
"A" stands for the type of animations. There were a total of eight different types of animations.
"M" stands for the movie DVDs advertised in the flash. There were a total of eight different movie DVDs.

Appendix H

Pretest, Control Checks, and Results of Experiment 2

Pretest: To select the appropriate searching task for Experiment 2, we pretested several searching tasks, for example, answering two questions for each article, identifying the positions of certain phrases in each article, searching for a specific phrase, counting how many times it appeared in each article, etc. We chose the searching task as searching for a specific phrase and counting how many times it appeared in each article for two reasons. First, the selected searching task was not too easy but required subjects to sufficiently focus on the task. Second, subjects would not take a long time to complete the selected searching task.

Control checks: We proceeded to conduct control checks. The subjects' general levels of interest were 3.40 (SD=1.16) for the articles and 2.96 (SD=1.24) for the DVDs, both on a Likert-scale from 1 to 7. Hence, the subjects exhibited medium levels of interest for both the articles and the DVDs. No subject reported having heard of any of the DVD titles before the experiment. In summary, the experiment materials used in the study were found to be appropriate. The mean comprehension score of articles was 9.53 (SD=2.87) out of 20. A repeated measures MANOVA was performed to confirm that none of the animation features or their interactions affected the subjects' comprehension of the articles: motion (F=0.410, p=0.525), lagging (F=0.687, p=0.412), looming (F=0.533, p=0.469), the two-way interaction between motion and looming (F=0.004, p=0.948), the two-way interaction between motion and lagging (F=0.045, p=0.833), the two-way interaction between looming and lagging (F=2.462, p=0.124), and the three-way interaction between the three animation features (F=1.434, p=0.238). As the subjects' comprehension of the articles was not significantly affected, we concluded that the animation manipulations were not intrusive to the subjects.

Table H1. Experiment 2 Results

		MANOVA		ANOVA			
Independent variables	**Dependent Variables**	***F***	***p***	**Condition**	**Marginal mean**	***F***	***p***
MO		0.387	0.681				
	Fixation count			**no MO**	1.833	0.011	0.916
				MO	1.856		
	Fixation Time			**no MO**	0.434	0.139	0.711
				MO	0.455		
LA		1.535	0.227				
	Fixation count			**no LA**	1.800	0.270	0.606
				LA	1.889		
	Fixation Time			**no LA**	0.417	1.351	0.251
				LA	0.472		
LO		1.493	0.236				
	Fixation count			**no LO**	1.822	0.059	0.808
				LO	1.867		
	Fixation Time			**no LO**	0.420	1.008	0.321
				LO	0.469		
MO*LA		2.840	0.069				
	Fixation count			**no MO + no LA**	1.767	0.056	0.814
				no MO + LA	1.900		
				MO + no LA	1.833		
				MO + LA	1.878		
	Fixation Time			**no MO + no LA**	0.423	0.453	0.504
				no MO + LA	0.445		
				MO + no LA	0.410		
				MO + LA	0.499		

LO*LA		0.600	0.553				
	Fixation count			**no LO + no LA**	1.733	0.381	0.540
				no LO + LA	1.911		
				LO + no LA	1.867		
				LO + LA	1.867		
	Fixation Time			**no LO + no LA**	0.377	0.984	0.327
				no LO + LA	0.463		
				LO + no LA	0.457		
				LO + LA	0.481		
MO*LO		0.641	0.532				
	Fixation count			**no MO + no LO**	1.700	1.231	0.273
				no MO + LO	1.967		
				MO + no LO	1.944		
				MO + LO	1.767		
	Fixation Time			**no MO + no LO**	0.381	1.271	0.266
				no MO + LO	0.487		
				MO + no LO	0.459		
				MO + LO	0.450		
MO*LA*LO		0.137	0.872				
	Fixation count			**no MO + no LO + no LA**	1.556	0.125	0.725
				no MO + no LO + LA	1.844		
				no MO + LO + no LA	1.978		
				no MO + LO + LA	1.956		
				MO + no LO + no LA	1.911		
				MO + no LO + LA	1.978		
				MO + LO + no LA	1.756		
				MO + LO + LA	1.778		
	Fixation Time			**no MO + no LO + no LA**	0.351	0.018	0.892
				no MO + no LO + LA	0.410		
				no MO + LO + no LA	0.495		
				no MO + LO + LA	0.479		
				MO + no LO + no LA	0.403		
				MO + no LO + LA	0.515		
				MO + LO + no LA	0.418		
				MO + LO + LA	0.483		

Note: "MO" stands for Motion, "LO" stands for Looming, and "LA" stands for Lagging.

Appendix I

Figure I1. Experiment Webpage Used in Experiment 3

Appendix J

Table J1. Effect Size and Statistical Power: Experiment 1 and Experiment 3

		Experiment 1				Experiment 3			
Independent variables	**Dependent variables**	***F***	***p***	**Effect size: Cohen's *f***	**Statistical power**	***F***	***p***	**Effect size: Cohen's *f***	**Statistical power**
MO	MANOVA	4.686	0.014*	0.47	0.757	3.265	0.040*	0.18	0.616
H1	Fixation count	8.382	0.006**	0.44	0.808	6.432	0.012*	0.18	0.713
	Fixation time	4.919	0.032*	0.34	0.583	5.668	0.018*	0.17	0.659
LA	MANOVA	2.012	0.146	0.31	0.393	0.715	0.491	0.08	0.170
H2	Fixation count	4.032	0.051	0.30	0.502	0.181	0.671	0.03	0.071
	Fixation time	2.668	0.109	0.25	0.359	0.035	0.851	<0.01	0.054
LO	MANOVA	4.118	0.023*	0.44	0.698	3.142	0.045*	0.18	0.598
H3	Fixation count	4.298	0.044*	0.31	0.527	6.092	0.014*	0.18	0.690
	Fixation time	7.058	0.011*	0.40	0.738	5.655	0.018*	0.17	0.658
MO*LA	MANOVA	0.957	0.392	0.21	0.205	0.51	0.601	0.07	0.133
H4 (null hypothesis)	Fixation count	0.532	0.470	0.11	0.110	0.536	0.465	0.05	0.113
	Fixation time	1.383	0.246	0.18	0.210	0.966	0.327	0.07	0.165
LO*LA	MANOVA	3.668	0.034*	0.41	0.645	1.236	0.293	0.11	0.267
H5 (null hypothesis)	Fixation count	7.325	0.010**	0.41	0.754	0.065	0.799	<0.01	0.057
	Fixation time	5.173	0.028*	0.34	0.604	0.304	0.582	0.04	0.085
MO*LO	MANOVA	4.337	0.019*	0.45	0.722	3.179	0.044*	0.18	0.603
H6	Fixation count	6.167	0.017*	0.37	0.680	6.261	0.013*	0.18	0.702
	Fixation time	8.872	0.005**	0.45	0.830	5.528	0.020*	0.17	0.648

Note: * p<0.05, ** p<0.01. "MO" stands for Motion, "LO" stands for Looming, and "LA" stands for Lagging.
Cohen (1988, p.285-287) suggests that small, medium, and large effect sizes could be represented as the *f* values of 0.10, 0.25, and 0.40, respectively. To report effect sizes for analyses of variance, we used Cohen's *f* values, as indicated by Kotrlik and Williams (2003). See Kotrlik and Williams (2003, p. 5) for a table of effect size magnitudes of different effect size measures.

Table J2. Effect Size and Statistical Power: Experiment 2

		Experiment 2			
Independent variables	**Dependent variables**	***F***	***p***	**Effect size: Cohen's *f***	**Statistical power**
MO	MANOVA	0.387	0.681	0.14	0.108
H1	Fixation count	0.011	0.916	< 0.01	0.051
	Fixation time	0.139	0.711	0.05	0.065
LA	MANOVA	1.535	0.227	0.27	0.308
H2	Fixation count	0.270	0.606	0.08	0.080
	Fixation time	1.351	0.251	0.18	0.206
LO	MANOVA	1.493	0.236	0.26	0.301
H3	Fixation count	0.059	0.808	0.03	0.057
	Fixation time	1.008	0.321	0.15	0.166
MO*LA	MANOVA	2.840	0.069	0.36	0.528
H4 (null hypothesis)	Fixation count	0.056	0.814	0.03	0.056
	Fixation time	0.453	0.504	0.10	0.101
LO*LA	MANOVA	0.600	0.553	0.17	0.143
H5 (null hypothesis)	Fixation count	0.381	0.540	0.10	0.093
	Fixation time	0.984	0.327	0.15	0.163
MO*LO	MANOVA	0.641	0.532	0.17	0.150
H6	Fixation count	1.231	0.273	0.17	0.192
	Fixation time	1.271	0.266	0.17	0.197

Note: * p<0.05, ** p<0.01. "MO" stands for Motion, "LO" stands for Looming, and "LA" stands for Lagging. Cohen (1988, p. 285-287) suggests that small, medium, and large effect sizes could be represented as the *f* values of 0.10, 0.25, and 0.40, respectively. To report effect sizes for analyses of variance, we use Cohen's *f* values, as indicated by Kotrlik and Williams (2003). See Kotrlik and Williams (2003, p. 5) for a table of effect size magnitudes of different effect size measures.

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