THE IMPACT OF ANIMATION ON VISUAL SEARCH TASKS IN A WEB ENVIRONMENT: A MULTI-YEAR STUDY

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Abstract

Research results from a previous study show that animation as non-primary information significantly reduces information-seeking performance in a web-based environment (Zhang, 1999, 2000). Furthermore, in a different study, Zhang (2001) finds that animation on the left side of a screen has a higher negative impact on task performance than animation on the right side; animation also has different impact on task performance depending on its onset timing. This paper reports an investigation on whether animation's location and timing impacts have changed over the years, as the Web has become a commodity and people are more used to animated online advertisements on the Web. The results from four experiments during the 1999-2003 period indicate that (1) animation as non-primary information still significantly affects information-seeking performance in almost all animated conditions, (2) animation retains the significant main effect on side: the left side has higher negative impact than the right side, (3) animation retains the significant main effect on onset timing, although (4) animation's onset timing effects have changed slightly over the years. We discuss the effects from a theoretical perspective as well as the practical implications for website designers and online advertisers in the design of effective webpages with animated online advertisements.

Keywords: Human-computer interaction, information seeking, visual attention, visual interference, animation, online advertising, experiment, multi-year study

Introduction

In the web environment, animations are popular objects that users encounter frequently, if not all the time. Animations can be found in online advertisements as well as certain web pages. In the web environment, most animations are non-primary information stimuli to users. In other words, they carry no information for users' information-seeking tasks or immediate information needs. An earlier study shows that animation as a non-primary information stimulus in the web environment affects user's information-seeking performance (Zhang, 1999, 2000). Furthermore, in a different study, Zhang (2001) finds that animation on the left side of a screen has a higher negative impact on task performance than animation on the right side; and animation also has different impact on task performance depending on its onset timing.

As the frequency and user familiarity with animations in the web environment increase, one may wonder whether animation's impact on information-seeking performance changes. Humans are good at adapting to their environments. It is thus reasonable to speculate that over time, animation's impact on information-seeking performance decreases. As a multi-year exploration, the objective of this study is to investigate whether this assertion is true. We still consider the type of animations that are non-primary information stimuli to users who search certain information on webpages. A series of four controlled experiments were conducted during a five-year period to investigate animation's impact on information-seeking performance, taking into account the timing of animation onset and location of animation on the screen. Subjects are measured for their information-searching performance, rather than recall.

This study provides empirical evidence, rather than speculation, on whether and how to use animation in webpages especially given that most web users are very familiar with animation-based online advertisements. The study helps find a balance between drawing attention and being too distracting while using animations on Web pages. As many more people need to search for information on the web, and encounter animations more frequently, research that investigates the actual effect of animation becomes increasingly important.

Hypotheses on Animation Timing and Location Impacts

It is widely believed that human attention is limited and allocated selectively to stimuli in the visual field (Lang, 2000; Pashler, 1998). Visual attention and perception research shows that objects in our peripheral vision can capture our attention (Driver and Baylis, 1989). The meaning of a non-attended stimulus is processed to a certain extent (Allport, 1989; Duncan, 1984; Treisman, 1991). Therefore, the available resources for attention on the pertinent information are reduced and information-seeking performance deteriorates (Miller, 1991; Spieler, Balota and Faust, 2000; Treisman, 1991). Utilizing this research, though cautioning for different stimuli exposure periods (milliseconds in many visual attention experiments vs. seconds in a Web-based environment), Zhang (1999, 2000) discovers animation's negative impact on task performance in a Web-based environment. In her consequent study on animation's location and onset timing effects, Zhang (2001) finds that some of the visual search theories such as stimulus onset asynchrony or SOA (Mayor and Gonzalez-Marques, 1994; Yantis and Jonides, 1990) do not support the onset timing effects from the experiment.

In communication research, Lang (2000) proposes the limited-capacity model in the context of television and radio to explain how messages interact with the human information-processing system. According to this framework, an individual either consciously or subconsciously selects which information in the message to attend to, encode, process, and store. The amount of the selected information is limited by the individual's processing resources. While the individual controls some aspect of the processing resources, the stimulus elicits orienting responses from individuals. Orienting responses are "automatic, reflexive, attentional responses to changes in the environment or to stimuli that people have learned signal important information" (Lang, Borse, Wise and David, 2002). A plausible note is that these responses occur within seconds, which is more applicable to a Web-based environment. Lang and colleagues (Lang et al., 2002; Reeves, Lang, Kim and Tartar, 1999) use this model to study the effects of different types of computer-presented messages. In one of their experiments, they investigate whether the presence of Web-based advertisement banners would elicit an orienting response. The results show that Web animated banners elicit an orienting response whereas static Web advertisement banners do not.

The following hypotheses are tested to see if they hold true over a period of time while subjects become more used to animations in the Web-based environment. These hypotheses are supported by the above theories in general and empirical evidence from previous studies (Zhang, 1999, 2000, 2001) in particular.

> Hypothesis 1a. Task performance is negatively affected by animation onset regardless of onset timing.
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> Hypothesis 1b. Animation that appears at the same time as the task has a smaller negative effect than animation that appears in the middle of the task
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> Hypothesis 1c. Animation that appears at the same time as the task has a smaller negative effect than animation that appears toward the end of the task.
>
> Hypothesis 1d. Animation that stays on during the task has a smaller effect than animation that appears and disappears repeatedly.
>
> Hypothesis 2. Animation on the left side of the screen has a stronger negative effect on tasks than animation on the right side of the screen.

Experiment Design and Conduct

In order to make the information-seeking tasks closer to reality and eliminate the effect of subjects' pre-knowledge of information content on the potential outcome, words (strings of letters) were used to form a nonsense paragraph. A target word could appear many times in the paragraph. A subject's task was to click all appearances of only the target word. A paragraph template determined the number of total display items, number of targets, and the exact location of each target. In order to make it possible to compare the change in performance over time under different conditions and to minimize the potential learning effect of target locations, templates with slightly different locations for targets were used in different conditions. For example, given the locations of targets in the baseline, Condition 1 could be one position off with left-right order, and Condition 2 had one position off with right-left order. Three different templates were used. Table 1 depicts this variation. Each task corresponded to one of the three templates. Order or learning effect was reduced, if not eliminated, by randomly ordering all the nine tasks for each subject.

Table 1. Target Item Distribution in Same Paragraph under Different Conditions

Template 1 (for baseline)	Template 2 (left-right, one position off)	Template 3 (right-left, one position off)
_ _ _ _ _ x _ _ _ x _ _ _ _ _ x _ _ _ _	_ _ _ _ o _ _ _ _ _ o _ _ _ o _ _ _ _ _	_ _ _ _ _ _ f _ f _ _ _ _ _ _ _ _ f _ _ _
_ _ x _ _ _ _ _ _ _ _ _ x _ _ _ _ _ x _ _	_ _ _ o _ _ _ _ _ _ o _ _ _ _ _ _ _ _ o _	_ f _ _ _ _ _ _ _ _ _ _ _ f _ _ _ f _ _ _
_ _ _ _ _ x _ _ _ _ _ _ _ _ _ _ x _ _ _ _	_ _ _ _ o _ _ _ _ _ _ _ _ _ _ _ _ _ o _ _ _	_ _ _ _ _ _ f _ _ _ _ _ _ _ _ f _ _ _ _ _
_ _ _ _ _ x _ _ _ _ _ x _ _ _ _ _ _ _ _	_ _ _ _ o _ _ _ _ _ _ _ _ o _ _ _ _ _ _ _ _	_ _ _ _ _ _ f _ _ _ f _ _ _ _ _ _ _ _ _ _

The experiment was designed as a within-subject factorial 2x4 design. The first independent variable was the location or side of the animation on the screen, left or right. The second independent variable was the time at which animation appears. Time 1 means the animation appeared at the beginning of the task or when the Web page was loaded. Time 2 was when the animation appeared roughly after the first word in the second half of the paragraph was clicked, Time 3 was the last quarter of the paragraph, and Time 4 the on-off-on starting at the beginning of the task. A no-animation condition was used as a baseline. Table 2 lays out the structure of the design. Each subject would do a total of nine tasks (2x4 plus baseline).

Table 2. Structure of the Experiment Study

Task ID	Time 1	Time 2	Time 3	On-off-on	Baseline
Left	1	2	3	4	0
Right	5	6	7	8	

Animations in this study had the following characteristics: bright color, fixed size of 200x200 pixels, moderate speed, fixed distance from the paragraph, and neutral images that had little to do with the content of the tasks. Example animations used were animals, objects such as airplanes and balls, and human faces.

Participants saw three Web pages associated with each of the nine tasks: pre-page, task-page, and post-page. A pre-page displayed the target that a subject was to look for in the task-page. A post-page gave an indication of task completion and a link leading to the next task. A task-page, with or without animation depending on the condition, had a nonsense paragraph with the target word appearing many times in positions determined by a template. Each word (target or non-target) in the paragraph was hyperlinked thus clickable and did not change color after being clicked. The Web page was refreshed after each click leaving no indication of which word was just clicked. Subjects were thus suggested to develop a strategy that would help memorize their current position in a task-page.

In order to encourage subjects to perform at their best level, cash-based prizes were offered: one first-prize ($30 or $40) for the best performer within a session and two or four second-prizes ($15 each) for the next two or four best performers (prize amount and numbers were dependent on experiment session sizes). Subjects were told to complete each task-page as accurately and quickly as possible. They were given the performance and accuracy formula used for data analysis. Subjects practiced with two tasks (not used in the competition) to familiarize themselves with the exercise before the competition started. Each subject then completed a total of nine tasks, followed by a questionnaire that collected data on demographic background, interference perception, and attitude toward animation. When everyone completed the questionnaire, the performance scores were calculated, best performers identified, and awards given. A computer server captured the time (the exact click on each word in the task-page, and the moment a subject entered a task-page and the moment s/he finished) and accuracy data.

The same experiment design was conducted four times during 1999 and 2003. All studies were conducted in campus computer labs with a campus wide LAN. Within the same experiment, the same setup was used for all participants. A Sun Sparc 5 was used as the server for the first two experiments (1999 and 2001); a Dell computer with a Linux operation system as a server for the last two experiments. Most sessions lasted less than fifty minutes. Netscape Communicator was used as the browser for 1999 study, while Internet Explorer was used for the other three studies. The subjects were volunteer students enrolled in a northeastern university in the United States, majoring in Information Systems & Technology, Information Studies, Telecommunication and Network Management, Linguistics, and Computer Engineering. Table 3 shows the demographic data of the subjects participating in these studies. Among the 102 subjects, only two reported red and green color blindness. Their results, however, did not indicate any effects caused by the color blindness. There is an upward trend on number of hours per week subjects spent on the Web over the past five years. With an average of 28 hours per week on the Web (standard deviation of 12 hours), it is reasonable to say that the subjects have a fair familiarity and experience with online animations now.

Table 3. Demographic Data of Participants in Four Studies

Year	N	Age *	Male	Classification			Color Blind	Hours per week on Web *
				Doctoral	Master	Undergraduate		
1999	25	30.1 (6.8)	32%	24%	76%	0%	0	20.1 (8.7)
2001	37	23.8 (5.2)	54%	0%	14%	62%	2 (R & G)	21.4 (10.8)
2002	27	25.7 (6.5)	59%	0%	56%	44%	0	26.5 (12.0)
2003	32	25.9 (4.3)	50%	25%	63%	13%	0	28.3 (12.4)

* mean (std)

Data Analysis and Results

Since subjects were told to complete each task as accurately and quickly as possible, they were aware that they could sacrifice one factor (e.g. accuracy) to achieve the other (e.g. time). Simply considering one of the two factors may not reveal the true phenomenon of animation impact. The performance scores, which are determined by the click accuracy and amount of time spent on the task-page, were used for the data analysis of the four experiments.

Different tasks may have a different number of targets. Subjects were encouraged to emphasize clicking all the targets and were told that the number of clicked targets was weighted more heavily (as the square value). They were also told that the number of wrong clicks would affect the accuracy of a task too. The following formula, where click accuracy is dependent on the number of correctly clicked targets, the number of wrong clicks, and the total number of targets, was thus used to calculate the click accuracy of a task:

$$CA = NumberOfClickedTargets^2 / (NumberOfTargets + NumberOfWrongClicks).$$

Performance scores were calculated by the formula:

$$P = 10000 * CA / TimeOnTaskpage$$

(The constant 10000 eliminates the decimal places of the p-scores)

A paired t-test was conducted to compare the baseline performance scores with each of the eight animation performance scores. This can illustrate whether a particular animation condition affected the information-seeking performance. Table 4 shows the paired t-test results for two-tail significance at $\alpha = .05$ level. The table shows a consistent pattern where all animation conditions affected information-seeking performance except the one where animation appeared on the right side at the beginning of the task.

Table 4. Paired t-test Comparing Bbaseline and Animation Conditions

Year	df	(t0 t1)	(t0 t2)	(t0 t3)	(t0 t4)	(t0 t5)	(t0 t6)	(t0 t7)	(t0 t8)
1999	24	3.269	5.191	3.969	4.578	1.952	3.918	3.329	4.380
		0.003	*0.000*	*0.001*	*0.000*	0.063	0.001	0.003	0.000
2001	36	5.000	6.417	6.030	7.369	0.857	6.802	3.930	4.925
		0.000	*0.000*	*0.000*	*0.000*	0.397	*0.000*	*0.000*	*0.000*
2002	27	3.906	6.894	4.989	3.927	-0.878	4.933	3.168	2.382
		0.001	*0.000*	*0.000*	*0.001*	0.388	*0.000*	*0.004*	*0.025*
2003	31	3.176	3.779	4.092	3.548	1.027	4.633	2.185	4.165
		0.003	*0.001*	*0.000*	*0.001*	0.312	*0.000*	*0.037*	*0.000*

** p (two-tailed) < 0.05*

A 2x4 full factorial ANOVA for within-subjects repeated measures on SIDE (left and right) and TIME (beginning, halfway, last quarter, and on-off-on) was conducted for each of the four studies, resulting in Table 5. Both SIDE and TIME have significant main effects consistently. The interaction effects of SIDE by TIME have not been consistent over the years.

Table 5. Tests of Within-Subjects Effects on Performance

Year	Effect	F	df	Sig.	Observed Power
1999	Side	13.463	1	*0.001*	0.940
	Time	17.727	3	*0.000*	1.000
	Side x Time	0.861	3	0.476	0.206
2001	Side	17.64	1	*0.000*	0.983
	Time	15.02	3	*0.000*	1.000
	Side x Time	3.347	3	*0.030*	0.709
2002	Side	18.845	1	*0.000*	0.987
	Time	9.248	3	*0.000*	0.990
	Side x Time	1.656	3	0.203	0.378
2003	Side	7.232	1	*0.011*	0.741
	Time	3.784	3	*0.021*	0.757
	Side x Time	3.219	3	*0.037*	0.680

Table 6. Pairwise Comparison of Performance for SIDE Effects

Year	(I) SIDE	(J) SIDE	Mean Diff (I-J)	Std. Error	Sig.
1999	Left	Right	-143.720	39.169	*0.001*
2001	Left	Right	-134.989	32.140	*0.000*
2002	Left	Right	-170.356	39.242	*0.000*
2003	Left	Right	-118.494	44.063	*0.011*

Table 7. Pairwise Comparison of Performance for TIME Effects

1999	**(I) TIME**	**(J) TIME**	**Mean Diff (I-J)**	**Std. Error**	**Sig.**
	1	2	205.533	33.778	*0.000*
		3	90.600	40.241	*0.034*
		4	225.453	39.504	*0.000*
	2	3	-114.933	29.643	*0.000*
		4	19.920	41.516	0.636
	3	4	134.853	49.105	*0.011*
2001	**(I) TIME**	**(J) TIME**	**Mean Diff (I-J)**	**Std. Error**	**Sig.**
	1	2	228.946	37.541	*0.000*
		3	96.144	32.018	*0.005*
		4	241.802	41.882	*0.000*
	2	3	-132.802	34.894	*0.001*
		4	12.856	39.151	0.745
	3	4	145.658	38.278	*0.001*
2002	**(I) TIME**	**(J) TIME**	**Mean Diff (I-J)**	**Std. Error**	**Sig.**
	1	2	249.025	48.355	*0.000*
		3	110.642	40.294	*0.011*
		4	162.160	55.191	*0.007*
	2	3	-138.383	46.131	*0.006*
		4	-86.864	64.675	0.191
	3	4	51.519	66.116	0.443

1999	**(I) TIME**	**(J) TIME**	**Mean Diff (I-J)**	**Std. Error**	**Sig.**
2003	(I) TIME	(J) TIME	Mean Diff (I-J)	Std. Error	Sig.
	1	2	155.740	53.617	*0.007*
		3	62.219	55.621	0.272
		4	126.177	49.349	*0.016*
	2	3	-93.521	43.592	*0.040*
		4	-29.563	51.413	0.569
	3	4	63.958	54.581	0.250

Detailed pairwise comparisons on SIDE (Table 6) show a consistent pattern that the mean difference of performance scores between LEFT and RIGHT side is significantly negative, indicating that performance is worse when animation is on the left side compared with the right side.

Pairwise comparisons on TIME condition (Table 7) indicate a change of impact over the years. During early years (1999 and 2001), subjects performed the tasks (1) more effectively in Time 1 condition than Times 2, 3, and 4, (2) less effective in Time 2 than Time 3, (3) more effectively in Time 3 than Time 4, and (4) with similar performance in Time 2 and Time 4. In other words, animation that appeared during the middle of a task had more negative effect than animation at the beginning or toward the end of the task. Furthermore, animation that appeared toward the end of the task has more negative effect than animation that appeared at the beginning; and animation that appeared on and off and on again has a similar effect to the animation that appeared during the middle of the task.

These differences have slightly changed during the recent years (2002 and 2003). The significant differences that remain are Times 1 and 2 (sig.), Times 1 and 4 (sig.), Times 2 and 3 (sig.), and Times 2 and 4 (non-sig.). Two pairs of comparisons have changed over the years, as indicated by ovals in Table 7: (1) the difference between Time 3 and 4 is not significant starting from 2002, and (2) the difference between Time 1 and Time 4 is not significant in 2003.

Discussion and Conclusion

Hypothesis 1a is supported in all but one case (see discussions that follow), and this has been consistent over the years. Hypotheses 1b, 1c, and 1d are all supported consistently. Animation that appeared in the middle or toward the end of the task had a larger negative impact than animation that appeared at the beginning of the task. On-off-on animations had a larger negative impact than stay-on animations. An explanation of Time 1's smaller impact may be habituation. According to Sokolov's (1963) *Comparator Theory of Habituation*, a user may "get used to" an animation that starts at the beginning of the task so that the impact of such animation is decreased over the rest of the task period. It is possible that when the animation onset occurs during the middle or toward the end of a task, or on-off-on, the unexpectedness elicits orienting responses and interferes with the search performance. This explanation seems to be consistent with a further analysis on some questionnaire comments that revealed that subjects were not expecting to see an animation once they started a task without an animation at the beginning. Thus, an animation popping up in the middle of the task turned out to be a surprise. Also, some subjects said they would not mind Time 1 animation as they "got used to it" after a while. They perceived that animations at the middle or the end of the task were more distracting compared with those at the beginning (over the four years, 47% considered Time 2 most distracting, 21% Time 3, 11% Time 1, and 12% not sure). Most considered that on-off-on was more distracting comparing to stay on ones (78% said on-off-on was more distracting, 10% stay-on, and 3% said on-off-on and stay-on were the same). This habituation effect is relatively short and does not seem to explain why subjects experience interference in each animated condition, even when they already knew and saw animations in previous tasks or during practice.

Hypothesis 2 is supported consistently over the years. One way of explaining the consistent side effect is that our habit of reading from left to right (on paper or on computer screen) requires us to attend to the left side more than to the right side, making the left side more attention resource demanding. An animation on the left side is closer to the beginning of the line. This location proximity increases the interference effect, as evidenced by many visual search studies. This also explains the only animation condition (right side and at the beginning of a task) that does not have a significant impact on search tasks. The animation is on the right side "far away" from the visually demanding beginning of each line thus would be less interfering. The performance results, however, are somehow inconsistent with subjects' perception of the distracting effect of side of animation. Among the four studies, 45% of the subjects considered the right side animation more distracting, 29% said the left side, and 20% said they were equally distracting.

Despite some studies showing that experienced Web users are less likely to be distracted by competing stimuli on the Web than novice users (Bruner II and Kumar, 2000; Dahlen, 2001; Diaper and Waelend, 2000), our study indicates that animation's interference effects have not changed much over the years and are still affecting experienced users such as the participants in our study. For the large part, subjects were not able to block the animations even though they knew animations have little to do with their tasks and some of them thought they were able to ignore the animations. This means that, to some extent, animation is processed involuntarily, a finding supported by major visual attention studies. For example, many researchers (Allport, 1989; Duncan, 1984; Miller, 1991; Yantis and Jonides, 1990) have argued that even though the processing of unattended stimuli can be attenuated with certain manipulations, it cannot be totally ruled out. The meaning of the unattended stimulus must be processed to some extent. Because our attention has a limited capacity, the available resources for attending the pertinent information is reduced, and thus information processing performance, including speed and accuracy, deteriorates (Driver and Baylis, 1989; Miller, 1991; Treisman, 1991). Our study also supports Lang's limited capacity model (Lang, 2000; Lang, Borse, Wise and David, 2002). That is, the onset of animation during an individual performing a task elicits an automatic, reflexive, and attentional response (i.e., orienting response) that affects the individual's task performance. Furthermore, due to this automatic and reflexive nature of responses, it is unlikely that animations as non-primary information have no impact on task performance at all.

There are some changes on animation's impact over the years. The noticeable change is the difference between different onset timing effects, in particular between Times 1 and 3, and between Times 3 and 4. Time 1 has had the least impact, while Time 4 has had close to the most impact. The change over the years indicates a convergence on onset timing effects, even though Times 1 and 4 are still significantly different. This is somehow puzzling and cannot be explained by the current data analyses. Thus, it is unclear what this change signifies. Further data analyses or additional studies may be needed.

This study presents empirical evidence of animation effects under different timing and location conditions from a multi-year perspective. This type of empirical evidence is scant and is very much needed for guiding current webpage designs to be more effective and efficient. With the number of Internet users increasing dramatically, webpages with animation and online ads affect millions of people seeking information on the Web, as well as advertisers who may benefit from online ads.

This study suggests similar strategies as previous studies (Zhang, 1999, 2000, 2001) for both website content providers and online advertisers, showing a dichotomy between the very different goals. Content providers want to make money from advertising, but also need to care about potential side effects of ads on their viewers' information-seeking performance. Given a choice, content providers could prefer ads with minimum distracting effects. Results from this study suggest that placing ads on the Web page earlier and on the right side should help reduce negative effects. Knowing that on-off-on animations have similar effects but generate larger negative perceptions and attitude, content providers may want to avoid this type of animations on their webpages.

On the other hand, online advertisers or marketers want to continue grabbing viewers' attention, knowing that the ads would be processed, to some extent, involuntarily. Thus, they would negotiate with content providers to put ads where viewers would be most affected, such as on the left side of the screen. They could also benefit from the timing strategy suggested by this study. For example, ads should appear after the user has been on a web page for some time. In other words, animation should appear when the user has already started reading or scanning the web page for some time. Also, advertisers may not have to have on-off-on animations on the screen. A caution of this suggestion is that this is based on animation's effect on task performance, not on recall of animation content or semantics. Further studies are needed to understand if on-off-on animations enhance recall better than stay-on animations.

This study, as well as previous ones, has investigated the effects of animation on visual search tasks under different conditions of location and timing. In these studies, the nature of the task (i.e., to find a sequence of non-meaningful letters) requires relatively low levels of information processing from respondents. Future studies may investigate how, if at all, animation affects respondents' performance in reading and comprehending a meaningful passage, a task that requires higher levels of information processing. Furthermore, the continual development of sophisticated software has allowed for more aggressive and intrusive advertisements on the Web. Animated online banners have usually been restricted to a specific location on a Web page. Current advertisers, however, are increasingly using animations "on the move." These types of animation do not stay in a specific location on a Web page. Instead, they move from one side of a Web page to another, demanding more user attention. Future studies should investigate whether "on the move" animations have a more deteriorating effect on users' performance of different tasks.

References

Allport, A. D. "Visual Attention," in Foundations of Cognitive Science (Ed., Posner, M. I.) MIT Press, Cambridge, MA, 1989, pp. 631-682.

Bruner II, G. C. and Kumar, A. "Web commercials and advertising hierarchy-of-effects," Journal of Advertising Research, (40:1/2), 2000, pp. 35-42.

Dahlen, M. "Banner advertisements through a new lens," Journal of Advertising Research, (41:4), 2001, pp. 23-30.

Diaper, D. and Waelend, P. "World Wide Web working whilst ignoring graphics: good news for web page designers," Interacting with Computers, (13:2), 2000, pp. 163-181.

Driver, J. and Baylis, G. C. "Movement and Visual Attention: The Spotlight Metaphor Breaks Down," Journal of Experimental Psychology: Human Perception and Performance, (15:3), 1989, pp. 448-456.

Duncan, J. "Selective Attention and the Organization of Visual Information," Journal of Experimental Psychology: General, (113:4), 1984, pp. 501-517.

Lang, A. "The limited capacity model of mediated message processing," Journal of Communication, (50:1), 2000, pp. 46-70.

Lang, A., Borse, J., Wise, K. and David, P. "Captured by the World Wide Web Orienting to Structural and Content Features of Computer-Presented Information," Communication Research, (29:3), 2002, pp. 215-245.

Mayor, J. and Gonzalez-Marques, J. "Facilitation and Interference Effects in Word and Picture Processing," in Cognitive Approaches to Human Perception (Ed., Ballesteros, S.) Lawrence Erlbaum Associates, 1994, pp. 155-198.

Miller, J. "The Flanker Compatibility Effect as a Function of Visual Angle, Attentional Focus, Visual Transients, and Perceptual Load: A Search for Boundary Conditions," Perception & Psychophysics, (49), 1991, pp. 270-288.

Pashler, H. E. The Psychology of Attention, The MIT Press, Cambridge, MA, 1998.

Reeves, B., Lang, A., Kim, E. and Tartar, D. "The effects of screen size and message content on attention and arousal," Media Psychology, (1), 1999, pp. 49-68.

Sokolov, Y. (1963) "Perception and the Conditioned Reflex." New York: The MacMillan Company.

Spieler, D. H., Balota, D. A. and Faust, M. E. "Levels of Selective Attention Revealed Through Analyses of Response Time Distributions," Journal of Experimental Psychology: Human Perception and Performance, (26:2), 2000, pp. 506-526.

Treisman, A. "Search, Similarity, and Integration of Features Between and Within Dimensions," Journal of Experimental Psychology: Human Perception and Performance, (17), 1991, pp. 652-676.

Yantis, S. and Jonides, J. "Abrupt Visual Onsets and Selective Attention: Voluntary versus Automatic Allocation," Journal of Experimental Psychology: Human Perception and Performance, (16), 1990, pp. 121-134.

Zhang, P. "Will You Use Animation on Your Web Pages? Experiments of Animation's Effects and Implications for Web User Interface Design and Online Advertising," in Doing Business on the Internet: Opportunities and Pitfalls (Eds, Romm, C. and Sudweeks, F.) Springer-Verlag in conjunction with the British Computer Society, 1999, pp. 35-51.

Zhang, P. "The Effect of Animation on Information Seeking Performance on the World Wide Web: Securing Attention or Interfering with Primary Tasks," Journal of Association for Information Systems, (1:1), 2000

Zhang, P. "The Impact of Animation Timing and Location on Visual Search Task Performance in the Web Environment," Proceedings of the Americas Conference on Information Systems (AMCIS'2001), Boston, MA, 2001, pp. 1361-1366.