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THE PERCEPTUAL LOAD EFFECT ON TARGET DETECTION IN BANNER BLINDNESS

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THE PERCEPTUAL LOAD EFFECT ON TARGET DETECTION IN BANNER BLINDNESS[4]

Perceptual load theory claims that the processing of task-irrelevant information can be predicted by the level of perceptual load. If a particular task places a high demand on attention, task-irrelevant stimuli processing can be prevented. That means that in a high-load condition the subjects are more likely to ignore distractors, while in a low-load condition, task-relevant information and task-irrelevant information are processed simultaneously. Although several studies showed that perceptual load can play a crucial role in inattentional blindness, there is a lack of applied research conducted using real-life tasks.

This study implemented a real-life task to describe the effect perceptual load has on banner blindness, which has common grounds with inattentional blindness. Banner blindness is a phenomenon in usability studies which shows that subjects do not notice webpage banners despite their saliency. The study represents an important application of load theory to the real-world behavior of internet users.

Participants were divided into low-load and high-load groups (which differed in number of stimuli presented) and asked to find items on a shopping website. In the critical trial, a banner appeared. The subjects under the high-load condition were expected to notice the banner less often, than under the low-load condition. The hypothesis was not supported. However, a tendency towards more reports about the banner's presence can be seen in the low-load group. We assume that if there are enough people who noticed the banner, we will be able to detect the effect of cognitive load on banner blindness.

Keywords: perceptual load, banner blindness, usability, visual search.

JEL Classification: Z

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Introduction

Intuitively, we believe that salient and distinctive objects always capture our attention, surprisingly this is not always true, and banner blindness dramatically illustrates this point. Banner blindness is a phenomenon in usability studies which shows that subjects do not notice banners on webpages despite their saliency.

Creating a webpage, designers try to attract our attention to a website's essential elements, so such elements are usually made big, colorful, and sometimes animated. However, experienced internet users learn to automatically overlook distractors (such as banners) that do not look like a part of the viewing content.

The term "banner blindness" was coined by Benway (1998) in a series of experimentally controlled usability studies. He created several versions of a website with a red rectangular banner. The participants were asked to search for 24 pieces of information. They were told that not all information was on the webpage. Control items could be found in the webpage's main body (texts), while experimental items were located in the banners. The results showed that experimental items were found 58% of the time compared with control items (94%).

Benway's explanation of the effect was that banners might be perceptually grouped with the page elements that are usually irrelevant to the user's task and do not contain any useful information, for example, a site title. He also highlighted that the banner in his experiment looked just like any other banner that users see every day, so they had learned to ignore banners and not waste time looking at them.

Numerous studies showed that experienced internet users choose an avoidance strategy that helps them avoid parts of the webpage that are not relevant to their current task (Hervet, Guérard, Tremblay, & Chtourou, 2011; Mosconi, Porta & Ravarelli, 2008). If some vital elements of a webpage look like advertising, users may mistake them for banners and lose important information that could affect the whole webpage's efficiency.

Previous studies have shown that banner blindness depends on various things, such as the banner's location, the subject's task, and experience (Albert, 2002; Lapa, 2007; Pagendarm & Schaumburg, 2001). We assume that the number of presented stimuli on the screen can also affect banner blindness, although this connection has not been studied yet.

In real-life tasks, banner detection can be considered task-irrelevant because users usually have a specific task while using the internet. We assume that the perception of advertisements can be predicted by the level of perceptual load (Lavie, 1995, 2005). Lavie claims that only irrelevant information will be excluded if the perceptual load (amount of information involved in the task-solving process) of relevant information exhausts all the available perceptual resources (Lavie & Tsal, 1994). Though Lavie does not give a clear definition of perceptual load in her papers, we define it as the amount of perceptual resources used, instrumentalized by the number of items presented on the screen.

Lavie argues that attention capacity has limitations, and if a particular task places a high demand on attention, task-irrelevant stimuli processing can be prevented. That means that subjects are more likely to ignore distractors in high-load conditions, while low-load task-relevant and task-irrelevant information are processed simultaneously. Previous studies showed that perceptual load affects inattentional blindness (Cartwright-Finch & Lavie, 2007; Murphy & Greene, 2016).

Inattentional blindness is a phenomenon when people fail to see salient but unexpected objects or stimuli. Studies started with Neisser (1979), who gave participants a task to follow one of two superimposed videos that showed people performing simple actions. When participants concentrated on one video, they often overlooked an unexpected event that happened in the other. For example, in one experiment, participants saw two groups of people playing basketball and were asked to count the passes of one of the teams (Neisser, 1979). Most of the subjects did not notice a woman with an umbrella crossing the room.

Some years later, Simons and Chabris (1999) demonstrated the same effect without superimposition. In their experiment participants were asked to count basketball passes by players in white shirts and ignore the second team's passes. Almost 50% of subjects overlooked a person wearing a gorilla suit that walked through the middle of the scene, looked at the camera, and left.

The possible interaction of perceptual load and inattentional blindness was shown in several studies. Cartwright-Finch and Lavie (2007) manipulated perceptual load by increasing the number of objects presented to a participant and making the visual search more demanding. Researchers modified the inattentional blindness cross-task procedure (Mack & Rock, 1998) to incorporate the manipulation of perceptual load and found an effect of perceptual load on the level of awareness. Only 10% of participants reported seeing an unexpected stimulus under high perceptual load, while in the low-load condition this number was five times larger. A visual search task was used in the second experiment. The results correlate with the first experiment, though the level of awareness increased in both groups. About 89% of subjects in the low-load condition and 50% of participants in the high-load condition reported seeing the unexpected stimulus. In the next two experiments, the researchers varied the load level from trial to trial using both tasks from the first two experiments. The results were also consistent with the previous findings.

Though the effect of perceptual load on inattentional blindness was demonstrated using various experimental paradigms and tasks (Macdonald and Lavie, 2008; Remington et. al, 2014), there is less applied research conducted on real-life tasks.

One such study is that of Murphy and Greene (2016). They investigated the role of perceptual load in inattentional blindness in drivers. Participants in a driving simulator were asked to drive and decide whether their car would fit in the space between other cars on the road. Low-load and high-load trials were intermixed, and trials 35 and 70 were critical (one low-load and one high-load). In the low-load condition, the right answer (whether the car fits or not) was quite obvious, while in high-load condition, it was more difficult to estimate the distance between the cars. The role of unexpected objects was played by a pedestrian or a large animal standing near the road. The level of inattentional blindness observed in the experiment was high: only 53% of drivers reported awareness of the critical stimulus under the low-load condition and 17% under high load.

Murphy and Greene provide evidence that the perceptual load theory can be applied to real-world behavior and influence everyday task performance. Internet users' behavior and usability studies are promising research fields to apply perceptual load theory. As the same mechanisms may be responsible for banner blindness and inattentional blindness, we applied perceptual load theory to banner blindness.

We manipulated the perceptual load and describe its effect on banner blindness. Our **research question** was: "How does perceptual load influence banner blindness?". The study **aimed** to implement load theory to a real-world task and describe its effect on banner blindness. **We hypothesized** that subjects under the high-load condition would be less likely to notice the banner, despite its saliency. Such a result would be in line with load theory and represent an essential application of perceptual load theory to internet users' real-world behavior.

Experiment 1

Method

From prior studies, we know that perceptual load may be manipulated with an increasing number of items presented on display (Lavie, 1995, 2005). We conducted an experiment where our **independent variable** with two levels was the number of presented stimuli (9 in the high-load condition and 4 in the low), and the **dependent variable** was the participant's ability to report the presence of the banner.

The final data analysis included 143 **participants**: 55 females and 88 males, mean age 36. The sample size was estimated with the help of G Power 3.1.9.4 (with expected effect size 0.3, α = 0.05, and power =.80). Participants were randomly divided into two groups with high and low loads.

The experiment was held online to obtain high ecological validity because users performed the task on their own familiar devices. The participants were recruited online via the online platform Yandex Toloka and received a $0.15 reward. All participants confirmed their voluntarily participation.

The participants were presented with a webpage: the interface was taken from the clothing store Barking Store (https://barkingstore.ru/) with permission from the owner. The ecological validity was ensured by using a real store and taking their t-shirts as stimuli. Before the experiment started, the subjects were asked to imagine that they had decided to buy some new t-shirts for the summer holidays.

Participants performed a standard visual-search task. The experiment consisted of 6 trials, the last of which was critical. Before each trial participants were shown a t-shirt with a specific print and instructed to find such a t-shirt. After the instructions, they were presented with the webpage with 9 or 4 different t-shirts (depending on the level of perceptual load). As soon as they found the t-shirt, the participants clicked on it, and then instructions with a new target print appeared (see *Figure 1).*

The high- and low-load conditions differed only in the number of t-shirts presented on the screen. *Figure 1* demonstrates the experimental design for the high load condition, while in the low-load condition there were 2 rows with 2 t-shirts each. The entire configuration (4 t-shirts) took up less screen space in the low load condition because the t-shirts were the same size in both conditions. This procedure is typical for experiments where the number of presented stimuli sets the perceptual load because the processing of relevant stimuli in the task is not as important as processing the irrelevant stimulus (banner), which is placed at some distance from the center of participant's attention.

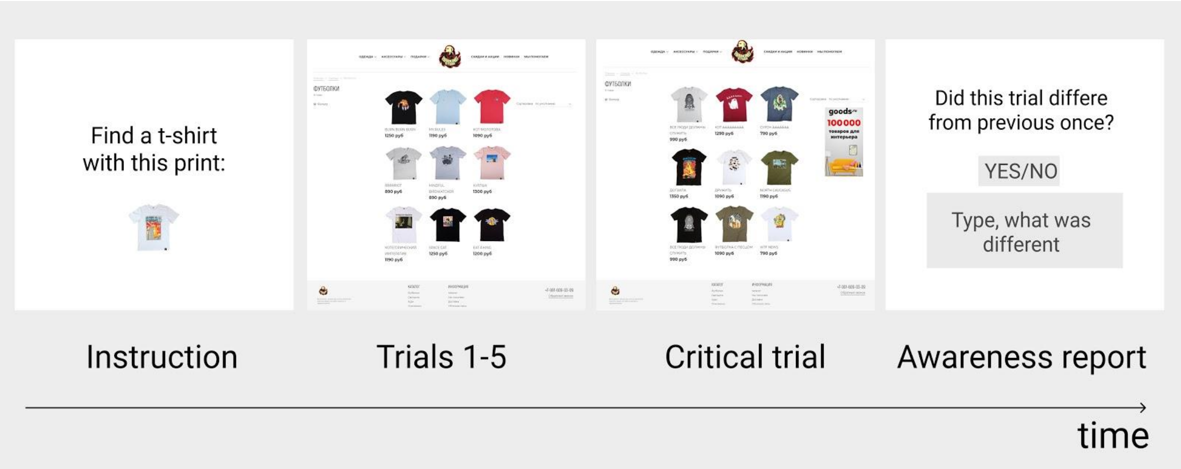

Figure 1. Experimental design for the high load group.

In the critical trial, a banner located on the right side of the page appeared (~4% of the screen width from the right edge). The banner size was 253 by 403 px. Immediately after the trial, participants were asked if this trial differed from the previous ones, and if they gave a positive answer, they were asked to type the exact difference. Those who answered negatively were presented with a question (yes/no), whether the trial contained a banner. If participants answered negatively, they were presented with the last trial again, but without a search task, and asked whether they saw a banner on the page. The participants who still did not notice the banner in that trial were excluded from the analysis because we cannot guarantee that they understood the task or knew what we meant by "banner".

Participants' awareness response (whether participants noticed the banner or not) and accuracy responses were measured.

We also asked participants whether they use ad blockers on their computers to estimate the influence of this factor on banner blindness as an additional variable.

Results

Data on the participant's response accuracy were collected. Subjects who made two or more mistakes in 6 trials were excluded from further analysis because we cannot guarantee the effect of load in such cases.

We also excluded participants who did the experiment more than once (users IPs and nicknames were collected and compared) and those who answered that the banner was not presented on the page even after the second demonstration. The final sample for analysis was 143 people.

The high-load group and low-load group did not differ in gender ($\chi^2(1, N= 143) = .064, p= .8$)), age (t (138.79)= -1.108, p = .269) or ad blocker usage ($\chi^2(1, N=143) < .001, p=1$)).

The awareness response was a categorical (yes/no) variable. A subject was considered aware of the critical difference if s/he wrote about seeing a banner (or advertisement) on the last trial and agreed that the last trial contained a banner. Only one person wrote unprompted that the last trial had a banner, so it was impossible to conduct a statistical test.

Nevertheless, we tested the null hypothesis about the equality of the disribution of answers in both groups for the subjects who agreed that the last trial contained a banner using the Chi-Square method and did not find a significant difference ($\chi 2(1, N=143) < .001, p=1$. See *Figure 2*).

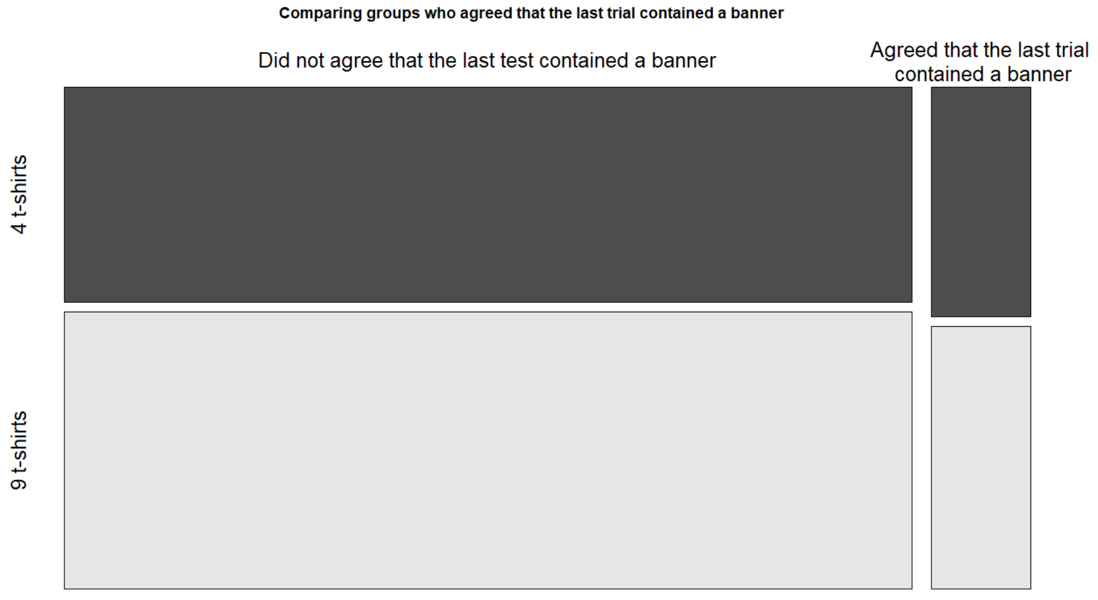

Figure 2.

Thus, the main hypothesis was not supported. The small number of participants who noticed the banner could be explained by the highly significant influence of banner blindness. The banner was located on the right side of the webpage and quite far from the center of the screen where the main focus of participant's attention was. We conducted a second experiment with the same design but make the banner more noticeable to increase the number of participants who noticed it and to get more data for analysis.

Experiment 2

Stimuli preparation

In order to make the banner more noticeable, we decided to change its position on the web page. We created pictures with four variations of banner location and conducted a short questionnaire in google forms. 34 subjects completed the form. They were asked to rate the banner's noticeability on the scale from 1 (not noticeable at all) to 10 (very noticeable). The questionnaire included the variant that was used in Experiment 1, but its salience was estimated as lower than several others. The most salient variant was chosen. It differed in location, being 15% of the screen width closer to the search field.

Method

The final data analysis included 373 **participants:** 153 females and 216 males and 4 participants chose option "other", the mean age was 37. The sample size was estimated with the help of G Power 3.1.9.4 (with expected effect size 0.2, α = 0.05, and power =.80). Participants were randomly divided into two groups with high and low loads. The participants were also recruited online via Yandex Toloka and confirmed their voluntarily participation.

The design of Experiment 2 was the same as in Experiment 1 and differed only in the banner's location.

In Experiment 2, we also collected the data about the participant's reaction time to control the time participants spent on a trial. Since participants were in natural conditions, we did not limit the time they spent on each trial, however, this may affect the result. If participants spend more time in the critical trial, the probability that they look at the banner is higher. Due to this effect all data that exceeded 3 σ was excluded from the analysis.

Results

Data about participant's response accuracy, reaction time (RT), and whether participants noticed a banner were collected. Participants were also asked whether they use ad blockers on their computers.

Participants who made more than two mistakes in 6 trials, participants who did the experiment more than once, participants who said that the banner was not presented on the page even after the second demonstration and participants who spent too long on the critical trial were excluded from further analysis.

The high-load group and the low-load group did not differ in gender (χ^2 (3, N=373)=4 .47, p= .214), age (t(370.6)= -0.318, p-value = .75) or ad blocker usage (χ^2(1, N=373)=1.106, p=.292).

A subject was considered aware of the critical difference if s/he wrote about seeing the banner (or advertisement) on the last trial and agreed that the last trial contained a banner. The banner's location closer to the participants' attention zone significantly increased the number of participants who noticed the banner: 23 of 372 participants wrote that the last trial had a banner compared to 1 in 143 in Experiment 1 (χ2(1, N=516)=5.7881, p=.01613).

Although, as we assumed, the number of participants who wrote that the last trial contained a banner was bigger in the low-load group, the findings were not significant (χ^2(1, N=372)= 2.1746, p= .1403. See *Figure 3*).

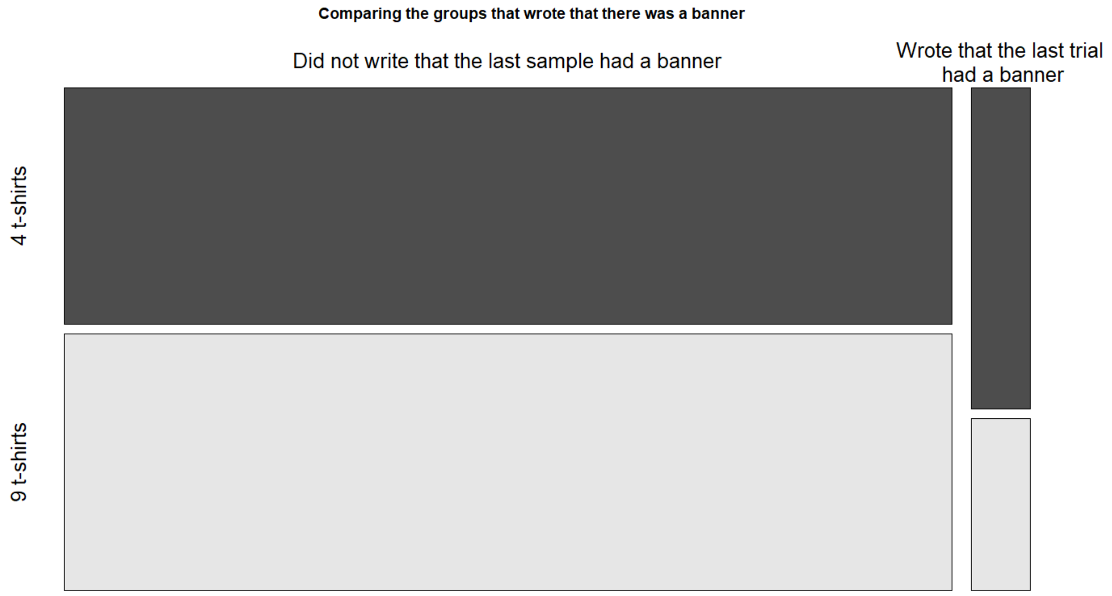

Figure 3.

We also compared groups by the number of participants who agreed that the last trial had a banner, but no significant differences were found ($\chi^2(1, N=372)=2.0395$, $p=.1533$. See *Figure 4*).

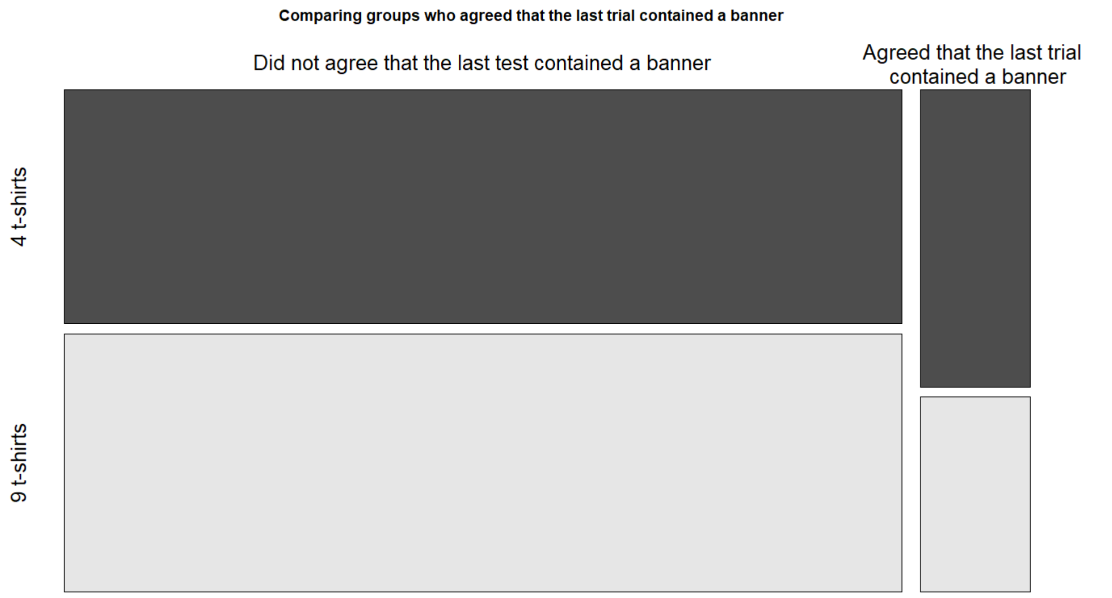

Figure 4.

We collected participants' reaction times and noticed that the low-load and high-load groups significantly differed in reaction time ($t(369.96)= -5.954$, $p<.01$). Such a result is typical for visual search tasks: the more stimuli set, the longer reaction time, because a visual search among fewer stimuli is faster than among more stimuli.

Discussion

Even though moving the banner's location closer to the participants' attention zone increased the number of participants who noticed the banner, the number is still relatively small (23 of 372), and in further research it would be worth making the banner even more noticeable so that at least half of all participants notice it. Choosing a brighter banner or one that stands out for its unusual content might also be useful.

General discussion

This study applied perceptual load theory to real-world behavior of internet users. Perceptual load theory predicts the processing of task-irrelevant information correlates with the level of perceptual load. The theory says that if a particular task places a high demand on attention, task-irrelevant stimuli processing can be prevented. In high-load conditions subjects are more likely to ignore distractors, while in low-load conditions subjects process task-relevant and task-irrelevant information simultaneously.

Participants were asked find a particular item on a shopping website, and in the critical trail, a banner appeared. We tested the **hypothesis** that subjects under the high-load condition would be less likely to notice the banner, despite its saliency. We expected users in the high-load condition (presented with 9 t-shirts on the screen) to notice banner less often than users in the low-load condition (4 t-shirts on the screen). The hypothesis was not supported. We found no significant difference between two groups. However, a tendency towards more reports about the banner's presence can be seen in the low-load group.

In her studies, Lavie gives no objective ways of measuring perceptual load. Prior studies show that the number of presented items can manipulate it. However, we do not know how many stimuli are needed to set the perceptual load to a specific level. The limitation of the current study may be connected with the fact that we cannot guarantee that the difference between 4 and 9 t-shirts is enough to distinguish the level of perceptual load between the groups. There are alternative ways that help to set the level of perceptual load, (e.g., the difficulty of the task) which may be also tested in future experiments.

In Experiment 1, we found a shift towards more banner detections in the low-load group, however, the number of subjects who noticed the banner was not significant. In Experiment 2, we made the banner more salient to increase the number of those who noticed it and get more data for analysis. The fact that more participants noticed the banner in the second experiment suggests that moving the banner's location closer to the participants' attention zone makes it more noticeable. This effect should be confirmed in further studies because this study's purpose was not the closeness of the banner to the attention area.

The number of banners noticed did not differ for those that use advertising blockers, which may indicate that this phenomenon does not depend on user experience.

The main limitation of the current study is the high level of banner blindness in natural conditions, which gave us a very few data to analyze. Almost 87% of participants did not notice the banner despite its saliency, indicating a high level of banner blindness in an online shopping task. Although we see a tendency towards more indications of the banner's presence in the low-load group, the number of participants who noticed the banner was so low, that there was insufficient data to compare the two load groups, even after making the banner more noticeable.

We assume that if enough people notice the banner, we will be able to detect the effect of cognitive load on banner blindness.

References

Albert, W. (2002). Do web users actually look at ads? A case study of banner ads and eyetracking technology. In Proceedings of the Usability Professionals Association 2002 Conference. Orlando, Florida.

Benway, J. P. (1998, October). Banner blindness: The irony of attention grabbing on the World Wide Web. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 42, No. 5, pp. 463-467). Sage CA: Los Angeles, CA: SAGE Publications.

Cartwright-Finch, U., & Lavie, N. (2007). The role of perceptual load in inattentional blindness. *Cognition*, *102*(3), 321-340.

Hervet, G., Guérard, K., Tremblay, S., & Chtourou, M. S. (2011). Is banner blindness genuine? Eye tracking internet text advertising. *Applied cognitive psychology*, *25*(5), 708-716.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology: Human perception and performance*, *21*(3), 451

Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in cognitive sciences*, *9*(2), 75-82

Lavie, N., & Tsal, Y. (1994). Perceptual load as a major determinant of the locus of selection in visual attention. *Perception & psychophysics*, *56*(2), 183-197.

Lapa, C. (2007). Using eye tracking to understand banner blindness and improve website design. Rochester Institute of Technology. RIT Digital Media Library. Available https://scholarworks.rit.edu/cgi/viewcontent.cgi?referer=https://scholar.google.ru/&httpsredir=1&article=1696&context=theses.

Macdonald, J. S., & Lavie, N. (2008). Load induced blindness. Journal of Experimental Psychology: Human Perception and Performance, 34(5), 1078

Mack, A., & Rock, I. (1998). *Inattentional blindness*. MIT press.

Mosconi, M., Porta, M., & Ravarelli, A. (2008). On-line newspapers and multimedia content: An eye-tracking study. In SIGDOC 2008 (pp. 55-64). Lisbon, Portugal: ACM Press

Murphy, G., & Greene, C. M. (2016). Perceptual load induces inattentional blindness in drivers. Applied Cognitive Psychology, 30(3), 479-483.

Neisser, U. (1979). The control of information pickup in selective looking. *Perception and its development: A tribute to Eleanor J. Gibson*, 201-219.

Pagendarm, M., & Schaumburg, H. (2001). Why are users banner-blind? The impact of navigation style on the perception of web banners. *Journal of Digital Information*, *2*(1), 14.

Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattentional blindness for dynamic events. *Perception*, *28*(9), 1059-1074.

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