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PERCEPTUAL LOAD EFFECT ON TARGET DETECTION IN BANNER BLINDNESS

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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, the task-irrelevant stimuli processing can be prevented. That means that in high load condition the subjects are more likely to ignore distractors, while in low load task-relevant and task-irrelevant information is processed simultaneously. Though several studies showed that perceptual load can play a crucial role in inattentional blindness phenomenon, there is a lack of applied researches conducted on real-life tasks.

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

Participants were divided into low-load and high-load groups (that differed in number of presented stimuli) and asked go online shopping. At the critical trail, a banner appeared. The subjects under high load condition were expected to notice the banner less often, then under low load. 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.

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Introduction

Intuitively we believe that salient and distinctive objects always capture our attention, surprisingly it 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 the webpage 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 even animated. However, it turned out that experienced internet users learn to automatically overlook different distractors (like banners) that do not look like a part of the viewing content.

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

J. Benway came up with a possible explanation of the effect: he believed that banners might be perceptually grouped with such page elements that are usually irrelevant to 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 just learned to ignore banners and not waste time looking at them.

Numerous studies showed that experienced internet users chose 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). Moreover, if some vital elements of a webpage look like advertisement, users may mistake them for banners and lose important information that could lose the whole webpage efficiency.

The previous studies have shown that banner blindness depends on various things, such as banner's location, 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, though that 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 surfing the internet. Thus, we assume that the perception of advertisement can be predicted by the level of perceptual load (Nillie Lavie, 1995, 2005). Nillie Lavie claims that only then 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 resources (Lavie & Tsal, 1994). Though N. Lavie does not give a clear definition of perceptual load in her papers, we will define it as the used amount of perceptual resources specified by the number of presented items on the screen.

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

Inattentional blindness is a phenomenon when people fail to see salient but unexpected objects or stimuli. The topic studies started with U. Neisser (1979), who gave participants a task to follow one of two superimposed videos that showed people performing some simple actions. It turned out that when participants concentrated on one video, they often overlooked an unexpected event that happened on the other. For example, in one experiment, participants saw two groups of people playing basketball and were asked to count 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, D. Simons and C. Chabris (1999) demonstrated the same effect even in a case 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 came in the middle of the playground, looked in a camera, and left the display.

The possible interaction of perceptual load and inattentional blindness was hinted in several studies. U. Cartwright-Finch and N. 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 manipulation of perceptual load. An effect of perceptual load on the level of awareness was shown. Only 10% of participants reported seeing an unexpected stimulus under high perceptual load, while in the low load condition, this number was five times bigger. 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 with low load and 50% of participants in the high load condition reported 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 a lack of applied researches conducted on real-life tasks.

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

The study by C. Murphy and G. Greene provides evidence that the load theory can be applied to real-world behavior and influence our everyday tasks' performance. Internet users' behavior and usability studies can be a great example of research fields where we can apply the load theory. As far as banner blindness has common grounds with inattentional blindness, and the same mechanisms may be responsible for their occurrence, we decided to apply the load theory to banner blindness in our research.

We decided to manipulate the perceptual load and describe its effect on banner blindness. Our **research question** was: "How does perceptual load influence banner blindness?". The current 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 load theory to Internet users' real-world behavior.

Experiment 1

Method

From prior studies, we know that the perceptual load level may be manipulated with an increasing number of presented items on display (Lavie, 1995, 2005). We conducted an experiment where our **independent variable** with two levels was the number of presented stimuli (9 in high load and 4 in low), and the **dependent variable** was the participant's ability to report about banners presence (awareness of a 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, $\alpha = 0.05$, and power =.80). Participants were randomly divided into two groups with high and low load.

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 special online platform Yandex Toloka and received a 0,15$ reward. All participants filled in a form, confirming their consent to participate voluntarily.

The participants were presented with a webpage: the interface was taken from a clothing store Barking Store (https://barkingstore.ru/). Permission to use the materials was previously obtained from the owner). The fact that we copied a real store and took their t-shirts as stimuli also speaks in favor of ecological validity. Before the experiment started, the subjects were asked to imagine that they decided to buy some new t-shirts for the summer holidays.

Participants performed a standard visual-search task. The experiment consisted of 6 total trials, and only the last of them 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 instruction, 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 instruction with a new target print appeared (see *Figure 1).*

High and low load conditions differed only in the number of presented t-shirts on the screen. So, *Figure 1* demonstrates the experimental design for the high load condition, while in the low load condition there appeared 2 rows with 2 t-shirts each. It is also important to note that 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, but such a procedure is typical for experiments where the number of presented stimuli sets perceptual load. That happens because the processing of relevant stimuli in the task is not as important as processing irrelevant one (banner), which is placed at some distance from the center of participant's attention.

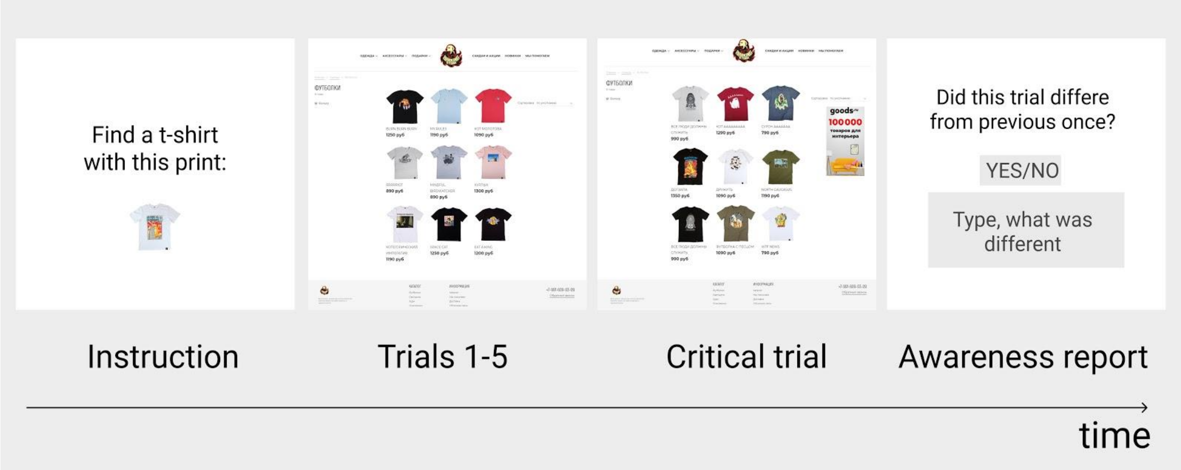

Figure 1. Experimental design for the high load group.

On the critical trial, a banner located on the right side of the page would appear (~4% screen from the right edge). The banner size was 253 by 403 px. Right 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 searching 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 as well as know what we meant by "banner".

Participants' awareness response (whether participants noticed a 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 accuracy responses were collected. Any subject who made two and more mistakes in 6 trials was excluded from further analysis because we cannot guarantee the effect of load in such a case.

We also excluded from analyses participants who passed the experiment more than one time (users IPs and nicknames were collected and compared), those who answered that the banner was not presented on the page even after the second demonstration. Consequently, the analysis included 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 blockers usage $\chi^2(1, N=143)< .001, p=1$).

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

Nevertheless, we tested the null hypothesis about equality of answers distribution in both groups (groups with high and low load) for the subjects who agreed that the last trial contained a banner using the Chi-Square method and did not find a significant difference ($\chi2(1, N=143)< .001$, $p=1$. See *Figure 2*).

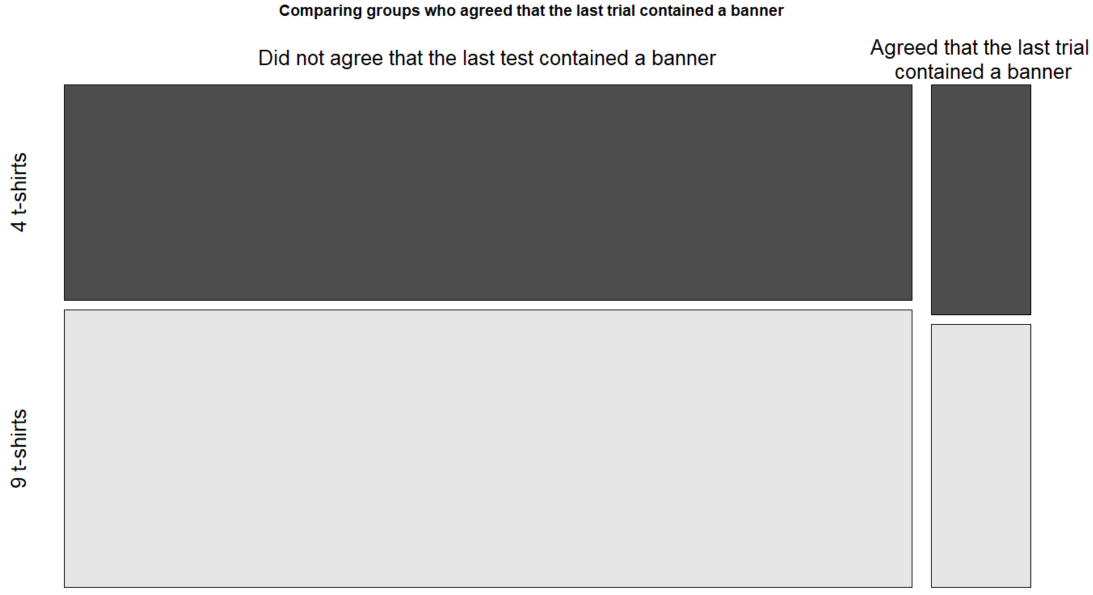

Figure 2.

That way, the main hypothesis was not supported. Such an incredibly small number of participants who noticed the banner could be explained by the excessively significant banner blindness influence. The banner was located at the right side of the webpage and quite far from the center of the screen where the main focus of participant's attention was. So that we decided to conduct the second experiment with the same design but make the banner more noticeable to increase the number of those who noticed it and get more data for the analyses.

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 filled the form. They were asked to rate banner's noticeability on the scale from 1 (not noticeable at all) to 10 (very noticeable). The questionnaire also contained the variant that was used in Experiment 1, but its estimate was lower than the several others. The variant that gained the highest estimate was chosen. It differed in the banner location, that was 15% of the screen closer to the search field (thus, it is placed at 19% of the right edge of the screen).

Method

The final data analysis included 373 **participants:** 153 females and 216 males and 4 participants chose option "other", mean age — 37). The sample size was estimated with the help of G Power 3.1.9.4 (with expected effect size 0.2, $\alpha = 0.05$, and power =.80). Participants were randomly divided into two groups with high and low load. The participants were also recruited online via Yandex Toloka and filled in a form, confirming their consent to participate voluntarily.

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 participant's reaction time to control the time participants spend on a trial. Since participants will be in ecological conditions, we will not limit the time they spend on each trial, however, it may affect the result. If some participants spend more time in a critical trial, the probability that they look at the banner will be higher. Due to this effect all such data (that overflew 3 σ) was excluded from the analyses.

Results

Data about participant's accuracy responses, reaction time (RT), and awareness response (whether participants noticed a banner or not) were collected. Participants were also asked whether they use ad blockers on their computers.

Any subject who made more than two mistakes in 6 trials, participants who passed the experiment more than one time, those who answered that the banner was not presented on the page even after the second demonstration and those, who spent too much time on the critical trial (the data that overflew 3 σ) were excluded from the further analysis.

The high load group and 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 blockers usage χ^2(1, N=373)=1.106, p=.292.

A subject was considered aware of a critical incentive if s/he wrote about seeing a banner (or advertisement) on the last trial and agreed that the last trial contained a banner. An essential result of the research is that 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 (χ2(1, N=516)=5.7881, p=.01613).

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

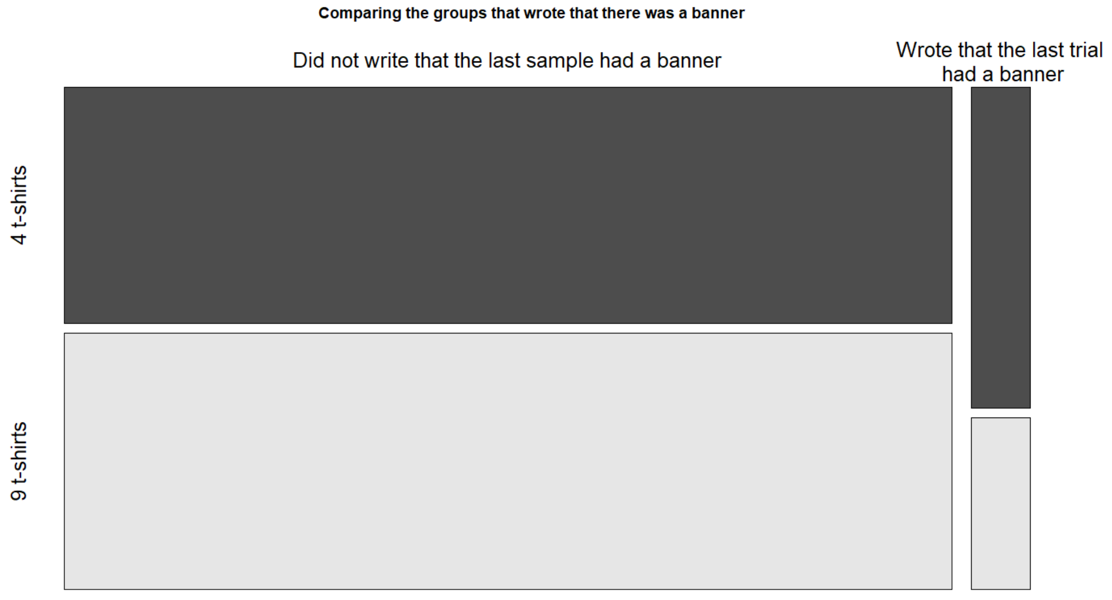

Figure 3.

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*).

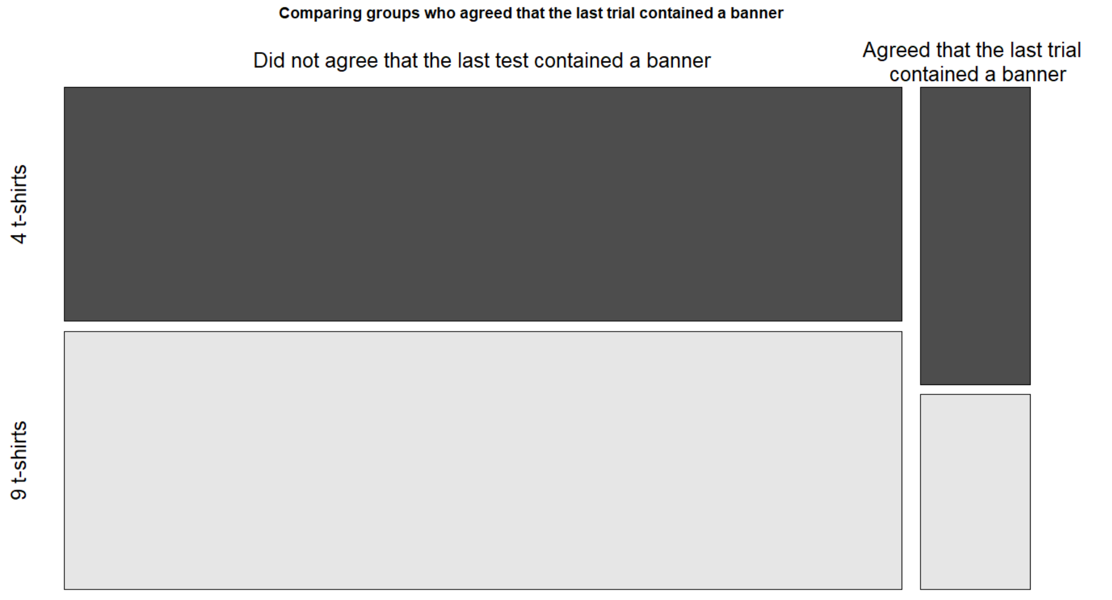

Figure 4.

Furthermore, we collected a participant's reaction time 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 becomes because visual search among fewer stimuli is faster than among more stimuli.

Discussion

Even though the approaching banner's location closer to the participants' attention zone increased the number of participants who noticed the banner, they are still relatively few (23 of 372), and in further research, it would be worth making the banner more noticeable so that at least half of all participants noticed the banner. Perhaps it makes sense to choose a brighter banner or a banner that stands out for its unusual content.

General discussion

The current study aimed to implement the load theory to real-world behavior of Internet users. Perceptual load theory predicts the processing of task-irrelevant information can be predicted by the level of perceptual load. Due to high demand on attention, placed by the main task, the task-irrelevant stimuli processing supposed to be prevented. According to the perceptual load theory, in high load condition the subjects are more likely to ignore distractors, while in low load process task-relevant and task-irrelevant information simultaneously.

Participants were asked to go online shopping, and at 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 (presented with 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, N. Lavie gives no objective ways of measuring perceptual load. From prior studies, we know that the number of presented items can manipulate it. However, we do not really know how many stimuli are needed to set the perceptual load 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 set the level of perceptual load in both groups. There are alternative ways that help to set the level of perceptual load, (e.g., the difficulty of the task) that may be also tested in future experiments in order to find the optimal one.

In Experiment 1 we found a shift towards more banner detections in low load group, however, the number of subjects who noticed the banner was not significant. So that in Experiment 2 we decided to make the banner more noticeable to increase the number of those who noticed it and get more data for the analyses. The fact that we see more answers about a banner's presence in the second experiment suggests that the approaching 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, and two weeks passed between the experiments, which makes it possible to influence the background's effect.

Also, the number of noticed banners does not differ in the use of 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 such ecological conditions, that gives us a very little data to analyze. Almost 87% of participants didn't notice the banner despite its saliency, indicating a high level of banner blindness in an online shopping task. Though we see a tendency towards more answers about banners presence in the low load group, the number of participants who noticed the banner was really low, so that we didn't have that much data to compare in two groups, even after making the banner more noticeable.

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.

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