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Web design's effect on user attention and information retention: an eye tracking study

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Abstract

Advertisements can be found all over the web, often accompanying articles and other texts that we consume on a daily basis. Debates around how technology affects us negatively, including internet marketing, are also nothing new. Therefore, this study aims to investigate the relationship between a subject’s level of distraction by web ads while consuming text, and their ability to retain the information presented in the text in their short-term memory. This is done through the lens of cognitive psychology, using the knowledge that the field has to present as ground work to develop the research questions and present four hypotheses. The study employed an experiment where a group of subjects was to read a text while distracted by ads, while a second group acting as a control group was to read only the text. Both groups were then immediately tested on their ability to remember what they had just read. The study finds that there may be evidence to show that ads could influence the users’ attention, but not necessarily distract them fully, although the evidence is - for multiple reasons - far from conclusive. Furthermore, the study does find that ads presented on the same page as a text in fact does seem to affect our short-term memory and our ability to remember the information directly following reading it.

Acknowledgement

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Introduction

One of the greatest limitations of humans is the inability to focus attention on multiple activities at the same time. Consequently, this issue has been of considerable concern to cognitive psychologists, raising questions such as how higher level cognition determines where to focus attention (Anderson, 2009, p.63). In addition, the extent to which a person is capable of retaining information to which they have just been exposed to, a very brief amount of time after exposure, given that they may (or may not) also have been distracted several times during their exposure, is a question that cognitive psychology has often been called upon to investigate (Anderson, 2009, p.186-187) and which this research will attempt to address. How all of the above is retained in short-term memory or working memory are furthermore issues which are relevant to this research and which will also be addressed.

Starting with attention, it is argued that serial bottlenecks in information processing are created when we try to focus our attention on more than one parallel processes (Anderson, 2009, p.63). In terms of how we choose what to focus on (as in which one of the parallel processes), there is a differentiation between goal-oriented factors and stimulus-driven factors (Anderson, 2009, p.64), as shown by the Corbetta and Shulman (2002) experiment (Anderson, 2009, p.64), and this differentiation seems to extend even biologically, with different parts of the brain being responsible for goal-oriented attention versus stimulus oriented attention (Anderson, 2009, p.64). Continuing, in general, it is supported that humans are able to pursue only one line of thought at a time (Anderson, 2009, p.81). Thus, it is of particular interest to attempt to identify which line of thought the mind will follow in situations where multiple distractions may interfere, such as while reading a text for example.

On a second level, an important role is being played by the working memory, i.e. the rehearsal process which does not store them in the long term memory (Baddeley 1986), and especially the articulatory loop through which an 'inner voice' rehearses information, but also the phonological loop which is the 'inner ear', that 'hears' the inner voice and then stores the information in a phonological form (Anderson, 2009, p.153), making it a 'support system' for keeping the information accessible. Moreover, the aforementioned systems seem to activate different regions of the brain (E.E. Smith & Jonides, 1995; Henson, Burgess & Frith, 2000; Henson, Burgess & Frith, 2000; Jonides et al., 1998) (Anderson, 2009, p.153). In addition, the word-length experiment (Baddeley, Thomson & Buchanan, 1975), besides proving the existence of the articulatory loop, also showed that the ability to rehearse items from the short-term memory decays over a very short period of time.

In the paper *‘Distraction effects of contextual advertising on online news processing: an eye-tracking study’*, by Wojdynski and Bang (2016) (which will act as a source of inspiration to this experiment because of its similarity), the authors discuss the effect of ads on the visual attention of readers of an online article when the ads are relevant or irrelevant respectively to the presented content, as well as the effect of relevant and irrelevant ads on the persuasiveness of the arguments of the content itself. The research concludes that readers spend more time looking at ads when they are relevant to the content, while it makes no difference if the ads are irrelevant to the content. Furthermore, it concludes that a text with relatively weak arguments may still result in a bigger attitude change of the subject, if it is presented together with ads relevant to the presented text.

All of this makes us ask ourselves how advertisements affect us while using the web on computers and mobile devices on a daily basis, specifically how it affects our ability to retain information from a text we’ve read on a web page with ads. Key to the question we ask ourselves is the view of online advertisements as attention grabbing distractions from the main content the user is on the page to view. This then leads us to pose the following two questions:

> Q1: To what extent does ads on a webpage distract a user who is reading an informative text on the page?
> Q2: Does the distraction of ads on a webpage lower the users ability to retain the information they just read in the short term?

Based on the above, an experiment will be conducted, aiming to show the effect of advertisements (with an average level of relevancy) on subjects' attention, while reading a given text, and their ability to memorize its content just after reading it. To achieve the first objective, eye-tracking software will be utilized to analyze pupil fixation at different points throughout the participant's reading of the text, as well as the time spent at each point, in order to then draw statistical conclusions (mean time, etc.). The attention analysis relies on the eye-tracking procedure because, it is known that ‘*a shift of attention often precedes the corresponding eye movement*’ (Anderson, 2009, p.70), a statement which is deduced from Posner, Snyder and Davidson (1980); Posner (1988). Moreover, Wojdynski and Bang (2016, p.4) in the aforementioned paper, state that *‘eye movements, in the form of pupil fixations within a particular area, are indicative of allocation of attentional resources to that specific area’*. Furthermore, the ability of the subject to retain the information as well as the quantity

of information they retained, will be extracted from a questionnaire which the subject will be tasked to fill out after reading the text. The questions of which will be multiple choice and will have increasing relative difficulty. After the completion, recall measures will be taken on the questionnaire via statistical analysis of the answers, so that deductions can be made out of them. Thus, the following four hypothesis are considered:

H1: Visual attention to the text will be greater when the text is presented without any distractions (ads) than when presented with distractions (ads)

H2: Visual attention to the text will be lesser when the text is presented with distractions (ads) than when presented without distraction (ads)

H3: The performance on the questionnaire will be higher when the text is presented without any distractions (ads) than when presented with distractions (ads)

H4: The performance on the questionnaire will be lower when the text is presented with distractions (ads) than when presented without any distractions (ads)

In conclusion, the outcome of the research will show and compare how ads can influence a person’s attention while reading a text on a webpage, and to what extent their retention ability is influenced by those ads.

Methodology

First of all, it should be mentioned that a deductive theory approach was adopted for this research, meaning that a theoretical question was based on already existing literature, research and experiments. The hypotheses are then deduced to be either supported or rejected in accordance with the data collected in the study (Bryman, 2012, p. 24).

To continue with the strategy that was used for the purposes of this research, a quantitative research approach was adopted, meaning that numerical data is collected in the attempt to show a relation between theory and the research (Bryman, 2012, p. 160-161). As for research design, the *between-subject* design was selected. Using this research design, every participant experiences only one of the independent variables. Differences between how participants tested under these variable conditions are then compared. The *within-subject* design was at one point considered but discarded for this particular study, because of practicality and limited sampling possibilities.

With the aforementioned strategy and research design, the following research methodology was then developed to define how the experiments were to be conducted.

Overview

The experiment will be conducted with 20 subjects. These subjects will be split into two groups of 10, and each individual from the two groups will be subjected to almost the same experiment. The only difference being the independent variable according to which of the two groups they belong to, as will be described further below.

Definitions of variables

Dependent variable

The dependent variable to be tested on every subject, will be their ability to retain information from the given text, in relation to their level of attention/distraction.

Independent variables

Distraction, varying between no distraction on the webpage for the first group, and distracting advertisement-like sections around the text for the second group.

Control variables

- Same text for both groups.
- Same physical environment.
- Same reading device conditions (device notification and sound turned off).
- Same noise level in the physical experiment environment..
- Subjects cannot have extensive knowledge about the subject presented in the text beforehand.
- Subjects are 'deceived', by being told that the eye-tracking software calibration is a software that tracks their facial expressions. A mock terminal app is used to make this statement more credible.
- Subjects are not told that their eyes are tracked beforehand, but only after they have finished the experiment.
- Subjects cannot have any distracting devices on them or in their field of view. Such devices need to have silent mode activated, and preferably be placed out of the subject's view. Furthermore, any kind of distraction (e.g. people walking by, a bird outside the window) should be minimized by the use of curtains or blinds.
- Subjects are not to be told about the questionnaire until after they have read the text, and are not to be explicitly told about the time limit either.
- Subjects of each group must both be told the same about the conditions being tested on them.

Subjects

All subjects sampled in the experiment were students from Stockholm University, both from DSV and other institutions, within the age range of 18-30. Although a clearly planned out sampling method was not laid out and followed, it can be said that the simple random sample method (Bryman, 2012, p.190) would be the closest actual sampling method to the one used.

Material

- Webpages (a distracting & and a non-distracting one, both fabricated by the researchers).
- Text to be read by the subject. The text is based on a newspaper article fed into ChatGPT (n.d.), which was then used to generate a similar article on the same theme. The generated article was then touched up by the researchers.
- Eye-tracking & statistical analysis software (GazeRecorder (n.d.))
- Questionnaire with questions related to the text.
- Consent Forms (structure and basic template was generated by ChatGPT (n.d.), and was then adapted and modified to suit our needs)

Procedure

Pre-experiment

- The subject enters and is greeted by and introduced to the researchers.
- The subject is asked to sit down to be introduced to the experiment.
- Researcher A gives a verbal introduction to what the experiment is about in brief terms, without revealing aspects that potentially would create unwanted bias, and what the experiment requires them as a subject to do.
- Researcher A presents the subject to the pre-experiment consent form, informs them of its contents, and asks them if they are willing to sign it after reading it.
- Researcher A then asks the subject if they are comfortable with reading in English, if they need glasses to read, and if they have dyslexia or any other neurological reading difficulties they are willing to disclose.

Experiment

- The subject is seated in front of the computer.
- Researcher B helps the subject calibrate the eye tracking software while telling them that the calibration process is something else, using a mock terminal-based program that seemingly calibrates its facial expression-analyzing ability.

- Researcher B gives the go ahead to start the experiment, i.e. to open their assigned webpage and start reading, and asks the subject to notify him when they are done.
    - The experiment will automatically shut down if more than 7 minutes is used to read the given text
- After the subject is done reading, Researcher B will thank them for reading and tell them that they will now be tasked with answering 8 questions on the computer, related to the text they just read.
- Now that the test has been completed the subject has completed the core part of the experiment.

Post-experiment

- Researcher A begins with asking the subject how the experiment felt, if they felt distracted, if they usually use ad-blockers on their devices themselves, and if ads distract and/or annoy them? The answers to these questions are not logged and documented to each individual subject, and only serve to help the researchers understand the overall sample better.
- Researcher A will now tell the subject about the actual conditions being tested, how it has been done, and what the actual goal of the study is.
- The subject is then presented and introduced to the post-experiment consent form by Researcher A, and is asked to sign that with their new knowledge and understanding of their participation in the study. If they do not wish to sign this consent form, all test results produced during their session will be discarded.

Design

The experiment will be conducted individually. The subject will sit in front of the computer. Both groups are not being told about the eye tracking software until the experiment is over, and are instead told that we are tracking their facial expressions. A mock terminal program that pretends to analyze facial expressions will be introduced in order to become more credible (Figure 1).

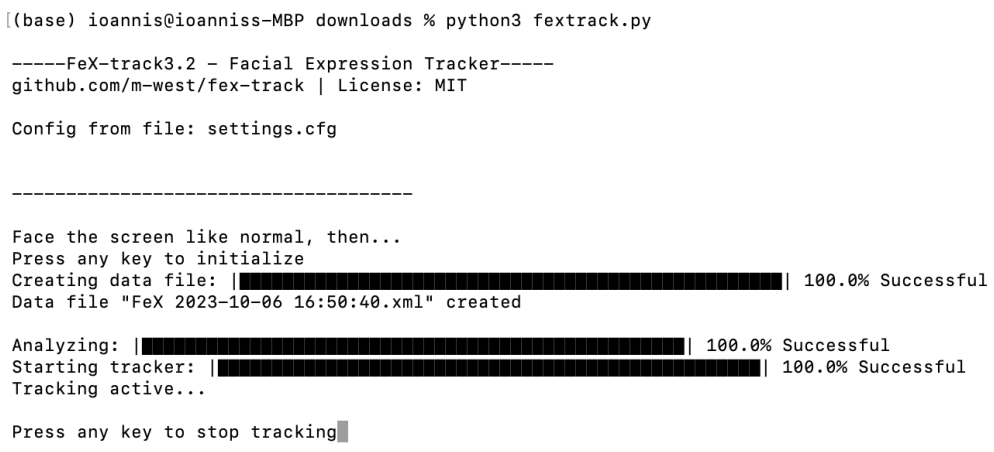


Figure 1: Mock terminal program for ‘tracking facial expressions’

After the mock program ‘calibration’, the actual eye tracking calibration will take place without letting them know what exactly it does. They are simply told that it is the second part of the facial expressions calibration and that they are to follow a dot on the screen with their eye. Eye tracking is achieved by connecting the software to the laptop’s built-in webcam.

Figure 2: Actual eye-tracking calibration (GazeRecorder)

The first group of participants will be subjected to the "distracting" website while also being asked to read the text as their eyes are being tracked. Participants in the second group on the other hand, will be subjected to the "non-distracting" website and asked to read the same text while their eye movements are tracked as well. Moreover, each subject from both groups will get 420 seconds (7 minutes) to read the text, an amount of time which was decided on after taking both the average time we needed ourselves to read the whole text (300 seconds - 5 minutes) and the average reading speed of an adult into consideration (Brysbaert, 2019). That being said, subjects are not informed about the existing time limit beforehand. After finishing reading, a short test/questionnaire will be handed to them in order to examine their ability to retain information from the text they just read.

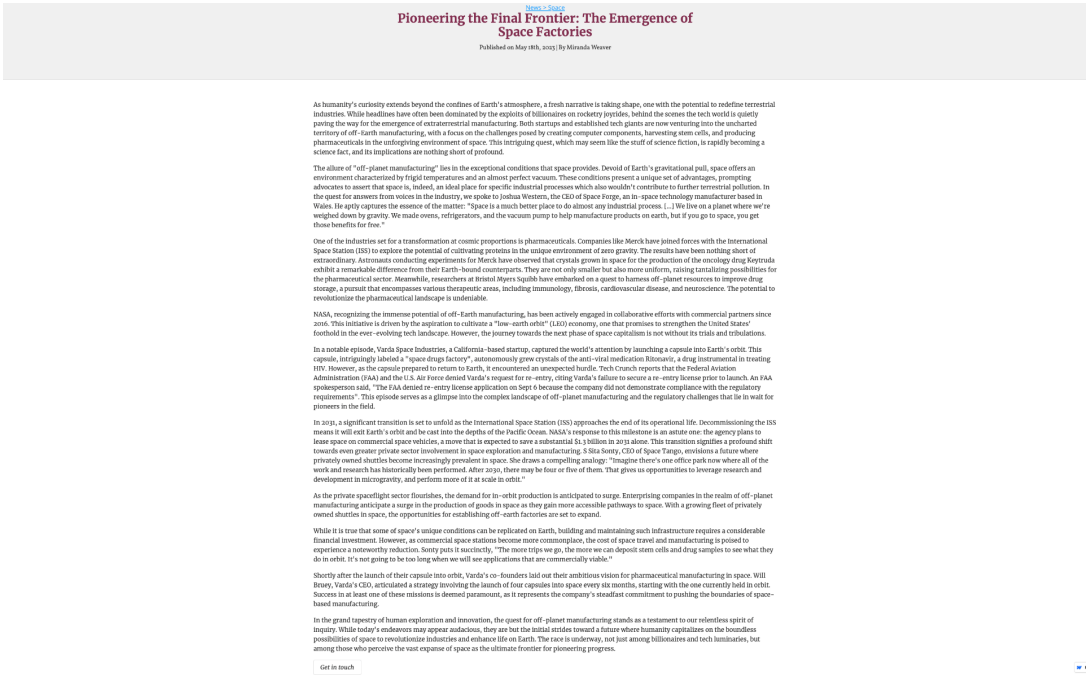
Group 1

Group 1's participants will be subjected to the 'distracting' website, the one which will have ads around it. The initial inspiration for the design of this website was the *Daily Mail Online (n.d.)*, even though the actual research webpage was not designed to be as content rich in the end. As for the ads, these were selected based on what was thought to be generally appealing for an average 18-30 years old student and were not related to the text. Furthermore, they are static meaning that they are not animated or have moving parts, presented as banners and rectangles floating around the text. No ads were placed in the middle of the text, as can be observed on some websites.

Figure 3: ‘Distracting’ Website

Group 2

Group 2’s participants will be subjected to the ‘non-distracting’ website, the one which will not have ads around it, but instead it will be a ‘clean’ webpage. The inspiration for designing this website was newspaper websites like the *Washington Post (n.d.)* and *Wikipedia (n.d.)*.



News > Space

Pioneering the Final Frontier: The Emergence of Space Factories

Published on May 18th, 2023 | By Miranda Weaver

As humanity's curiosity extends beyond the confines of Earth's atmosphere, a fresh narrative is taking shape, one with the potential to redefine terrestrial industries. While headlines have often been dominated by the exploits of billionaires on rocketry joyrides, behind the scenes the tech world is quietly paving the way for the emergence of extraterrestrial manufacturing. Both startups and established tech giants are now venturing into the uncharted territory of off-Earth manufacturing, with a focus on the challenges posed by creating computer components, harvesting stem cells, and producing pharmaceuticals in the unforgiving environment of space. This intriguing quest, which may seem like the stuff of science fiction, is rapidly becoming a science fact, and its implications are nothing short of profound.

The allure of "off-planet manufacturing" lies in the exceptional conditions that space provides. Devoid of Earth's gravitational pull, space offers an environment characterized by frigid temperatures and an almost perfect vacuum. These conditions present a unique set of advantages, prompting advocates to assert that space is, indeed, an ideal place for specific industrial processes which also wouldn't contribute to further terrestrial pollution. In the quest for answers from voices in the industry, we spoke to Joshua Western, the CEO of Space Forge, an in-space technology manufacturer based in Wales. He aptly captures the essence of the matter: "Space is a much better place to do almost any industrial process. [...] We live on a planet where we're weighed down by gravity. We made ovens, refrigerators, and the vacuum pump to help manufacture products on earth, but if you go to space, you get those benefits for free."

One of the industries set for a transformation at cosmic proportions is pharmaceuticals. Companies like Merck have joined forces with the International Space Station (ISS) to explore the potential of cultivating proteins in the unique environment of zero gravity. The results have been nothing short of extraordinary. Astronauts conducting experiments for Merck have observed that crystals grown in space for the production of the oncology drug Keytruda exhibit a remarkable difference from their Earth-bound counterparts. They are not only smaller but also more uniform, raising tantalizing possibilities for the pharmaceutical sector. Meanwhile, researchers at Bristol Myers Squibb have embarked on a quest to harness off-planet resources to improve drug storage, a pursuit that encompasses various therapeutic areas, including immunology, fibrosis, cardiovascular disease, and neuroscience. The potential to revolutionize the pharmaceutical landscape is undeniable.

NASA, recognizing the immense potential of off-Earth manufacturing, has been actively engaged in collaborative efforts with commercial partners since 2016. This initiative is driven by the aspiration to cultivate a "low-earth orbit" (LEO) economy, one that promises to strengthen the United States' foothold in the ever-evolving tech landscape. However, the journey towards the next phase of space capitalism is not without its trials and tribulations.

In a notable episode, Varda Space Industries, a California-based startup, captured the world's attention by launching a capsule into Earth's orbit. This capsule, intriguingly labeled a "space drugs factory", autonomously grew crystals of the anti-viral medication Ritonavir, a drug instrumental in treating HIV. However, as the capsule prepared to return to Earth, it encountered an unexpected hurdle. Tech Crunch reports that the Federal Aviation Administration (FAA) and the U.S. Air Force denied Varda's request for re-entry, citing Varda's failure to secure a re-entry license prior to launch. An FAA spokesperson said, "The FAA denied re-entry license application on Sept 6 because the company did not demonstrate compliance with the regulatory requirements". This episode serves as a glimpse into the complex landscape of off-planet manufacturing and the regulatory challenges that lie in wait for pioneers in the field.

In 2031, a significant transition is set to unfold as the International Space Station (ISS) approaches the end of its operational life. Decommissioning the ISS means it will exit Earth's orbit and be cast into the depths of the Pacific Ocean. NASA's response to this milestone is an astute one: the agency plans to lease space on commercial space vehicles, a move that is expected to save a substantial $1.3 billion in 2031 alone. This transition signifies a profound shift towards even greater private sector involvement in space exploration and manufacturing. S Sita Sonty, CEO of Space Tango, envisions a future where privately owned shuttles become increasingly prevalent in space. She draws a compelling analogy: "Imagine there's one office park now where all of the work and research has historically been performed. After 2031, there may be four or five of them. That gives us opportunities to leverage research and development in microgravity, and perform more of it at scale in orbit."

As the private spaceflight sector flourishes, the demand for in-orbit production is anticipated to surge. Enterprising companies in the realm of off-planet manufacturing anticipate a surge in the production of goods in space as they gain more accessible pathways to space. With a growing fleet of privately owned shuttles in space, the opportunities for establishing off-earth factories are set to expand.

While it is true that some of space's unique conditions can be replicated on Earth, building and maintaining such infrastructure requires a considerable financial investment. However, as commercial space stations become more commonplace, the cost of space travel and manufacturing is poised to experience a noteworthy reduction. Sonty puts it succinctly, "The more trips we go, the more we can deposit stem cells and drug samples to see what they do in orbit. It's not going to be too long when we will see applications that are commercially viable."

Shortly after the launch of their capsule into orbit, Varda's co-founders laid out their ambitious vision for pharmaceutical manufacturing in space. Will Bruey, Varda's CEO, articulated a strategy involving the launch of four capsules into space every six months, starting with the one currently held in orbit. Success in at least one of these missions is deemed paramount, as it represents the company's steadfast commitment to pushing the boundaries of space-based manufacturing.

In the grand tapestry of human exploration and innovation, the quest for off-planet manufacturing stands as a testament to our relentless spirit of inquiry. While today's endeavors may appear audacious, they are but the initial strides toward a future where humanity capitalizes on the boundless possibilities of space to revolutionize industries and enhance life on Earth. The race is underway, not just among billionaires and tech luminaries, but among those who perceive the vast expanse of space as the ultimate frontier for pioneering progress.

Get in touch

Figure 4: ‘Non-Distracting’ Website

Text

The text is based on a newspaper article from The Guardian (Demopoulos, 2023) fed into ChatGPT (n.d.), which was then used to generate a similar article on the same theme. The generated article was then touched up by the researchers. The text is 1070 words long and is about the emergence of space factories and manufacturing in earth orbit. What is important to highlight again, is that the text was exactly the same for both groups.

Questionnaire

As already mentioned before, subjects belonging to both groups were after having read the text asked to complete a questionnaire with 8 questions. The questions were generated by ChatGPT (n.d.) after it had generated the text, and also verified by the researchers. The questions are closed format, meaning that each one has 4 options from which one is correct each time. The questions are of varying difficulty, some of them being trick-questions on purpose. The questions were presented to the subject in a Google Form submission form, to facilitate the data collection and its subsequent analysis.

To explain the reason behind the closed format questions, Bryman (2012 p. 249-261) is examined. Starting with, they are easy to process questions, while they also facilitate the comparability of answers and reduce their variation. That is to say it would be hard to determine which answers are correct in an open form questions scenario. However, forced-choice answers present some drawbacks, one of them being that it might irritate some subjects when they cannot find the response they are looking for, in the provided options. As it was already mentioned though, we included some ambiguous options for answers to certain questions on purpose, so that it can be distinguished which subjects were really paying attention when reading the text, and if they did to what extent the information was retained.

Research ethical issues

The ethical considerations of this study were developed using the Swedish Research Council’s (2017, p. 30-32) guidelines.

The subject must be completely aware of the experiment as well as about its outcomes, before or after the experiment is materialized. Because we would like our experiment to be unbiased (i.e. causing unwanted increased consciousness of one's eye movement), we chose to split the consent form in two. The first one concerns the consent of participating in the experiment, while the second one covers the whole experiment including the use of the results produced by the subject. Most importantly to give us consent to use the data received from the eye-tracking software even though the subject was not aware of the eye-tracking beforehand. Also, the following set of rules will be adopted:

- A subject can end the experiment early whenever they want if they so wish.
- Everything is anonymous and no personally identifiable data of any participant shall be included in the final report
- If a subject, after the experiment is materialized, decides that he/she does not want his/her data to be included, then we have the obligation to immediately exclude, discard and erase the subject and its data from the experiment and our records.

Results

Time spent focusing on the text

The experiment was conducted on 26 students, but because of technical difficulties, only the 20 of them were eligible to be included in the studies. *Figure 5*, shows the average value from each subject group (percentages were used because each subject's total time spent reading varied as some of them might have finished reading in shorter time compared to others), while *Figure 6* presents the combined and averaged heatmaps (processed in Photoshop) produced by the two groups on the two websites respectively. The images were created by averaging the heatmaps of all subjects from each group.

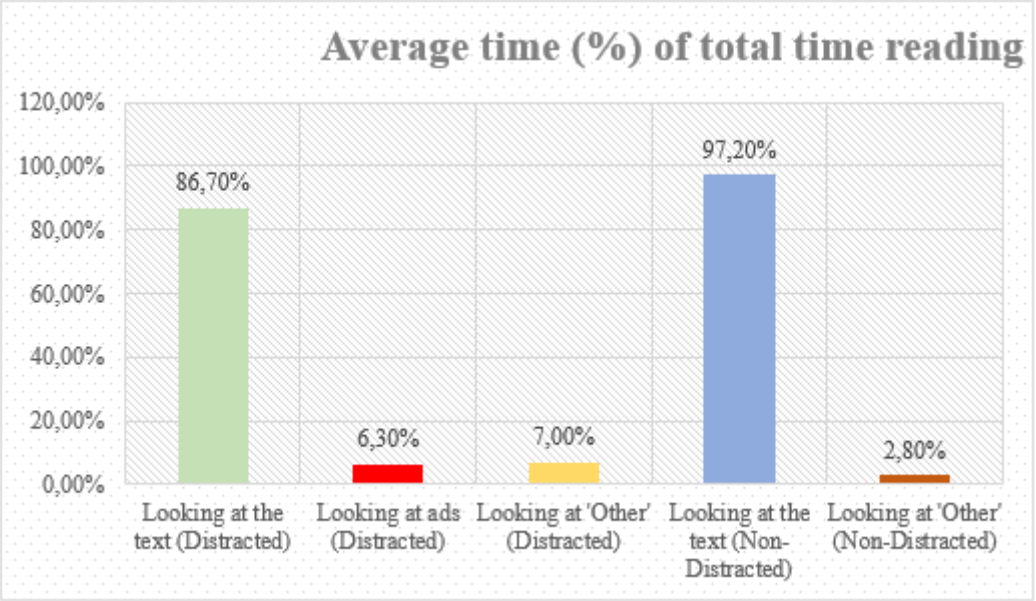


Figure 5: Average Time Spent-Graph

Technical difficulties

An important and unfortunate matter, which needs to be pointed out is that unexpected technical difficulties have impacted our ability to come to a solid conclusion, especially for H1 and H2. The eye-tracking software would suddenly, supposedly due to a service update, not allow for more than 60 second sessions after performing 13 successful experiments (10 successful for Group 1, and 3 successful for Group 2). As mentioned previously, the allowed reading time given to the subjects was otherwise seven minutes. This means that eye-tracking data was only collected on three subjects of Group 2 (the 'non-distracted' one). To still collect data on this group and to be able to at least find results

for H3 and H4, the remaining seven subjects only had questionnaire performance data collected on them. However, in an attempt to salvage the data we still collected and to show at least weak results for H1 and H2, we conducted a statistical prediction through regression analysis on the data collected on Group 2, after finding the statistical equations which satisfied the plot with the time spent on looking at the text by the three subjects (out of the total 10) we performed the full experiment on. It was found that the confidence interval of the solution was approximately ±1.437 with a confidence level of 95%. This means that if we had done more experiments, that percentage would fall into the range of 95.3 ±1.437 with a certainty of 95%. The aforementioned analysis can be found in *Appendix A*.

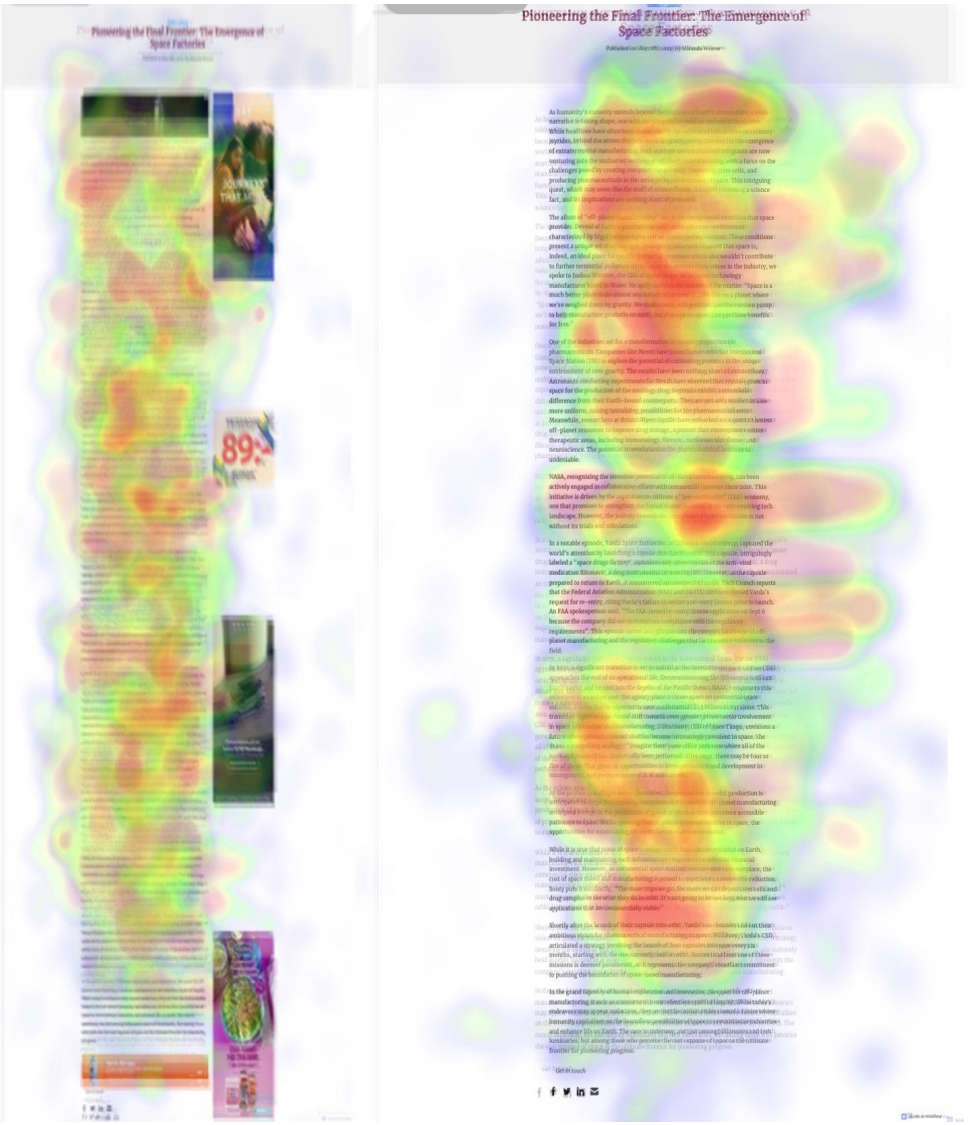


Figure 6: Averaged Heatmaps of Group 1’s (left) and Group 2’s (right) subjects

The differences in time spent looking at the text were not significant between subjects of the two groups. Group 1's subjects spent an average of 86,7% of their whole reading time looking at the text, while Group 2's subjects spent an average of 97,2% of their whole reading time looking at the text. This constitutes a difference of 10,5% between the two groups. As expected then, individuals reading a website without ads spent more time looking at the actual text in contrast with individuals reading a website with ads. But deviations and observed inaccuracies in the outputs given by the eye-tracking software, not even considering that Group 2's result stem from only 30% of the subjects in the group, make us doubt the accuracy of these numbers. If we then add the fact that Group 2's eye tracking results are based on only a small portion of their subjects, we ask ourselves whether these results would be very different under better circumstances. That being said, under these conditions, a difference in the time spent giving attention to the text was still found. Thus, we are only able to find weak, partial support for H1 and H2.

A subject of further interest is that not even one subject that we performed the experiment on, spent more than 96% of their reading time looking at the text, regardless of the group they belong to. What is a subject presented with a text and no ads spending 4% of their time looking at? Furthermore, another observation is that Group 1's subjects spent an average of 6.3% of their reading time looking at the ads.

By analyzing the results, it was found that in both groups there was a small percentage of the total reading time (7% average in Group 1 and 2.8% average in Group 2), time labeled as 'Other', defined as time not spent looking at the text nor the ads (if available). This means that the subject was supposedly looking at blank locations on the website, away from the screen, or that this might have occurred due to the eye-tracking software being inaccurate or having more unknown errors. A theory is that because the tracking only used the webcam to follow the user's eyes, the area in which the software judged the user to be looking was so big that it would bleed into blank space for ~3-6.7% of the time. Thus, the time spent looking at 'Other' may just be time spent reading words on either outer side of the text, which in turn because of a bleeding effect, was picked up as looking (or merely gazing) at something that wasn't being tracked.

Questionnaire performance

Figure 6, shows the average values from each subject group of the mean, median and mode statistical averages. Below, a short explanation of these averages is provided.

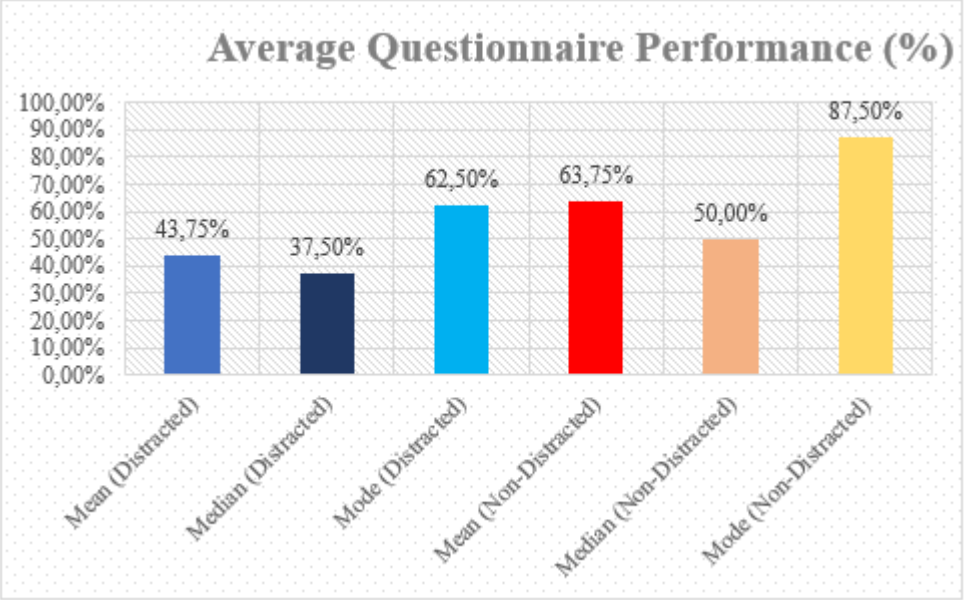


Figure 7: Average Questionnaire Performance

To start with, the mean values refer to the number of correctly received responses, on average, by each group. The median values refer to the result that ends up in the middle if the results are listed sequentially from lowest to highest, by each group's subject. Lastly, the mode values refer to the most common value in the dataset, i.e. the most frequent number of correct answers received by each group's subject.

Analyzing the above results, it can be concluded that Group 1 correctly responded to only 3.5 / 8 questions (~43.75%), on average, while Group 2's participants correctly answered 5.1 / 8 questions (63.75%), on average. The difference of 20% in the mean average result between the two groups is quite significant. Thus, H2 and H3 were supported.

In addition to the mean average, Group 1's median was 3 / 8 questions answered correctly (37.5%), while the same metric was 4 / 8 (50%) for Group 2 . Moving on, the most frequent number of correctly answered questions was 5 / 8 (62.5%) among Group 1's participants and 7 / 8 (87.5%) among Group 2's participants.

The rather high mode displayed in Group 1's results shows that a good few subjects did rather well (on par with the mean result of Group 2) even though they were presented with distracting elements. The low mean shows that the average is lowered as a result of

many low scores, as further supported by the low median. On the other hand, the difference between Group 2’s mean and median still shows a spread of low scores by this group’s subjects as well. The mean is increased by the relatively frequent high score of 7 / 8. We speculate, purely based on minor observations and conversation with some Group 2 subjects, that since they were only presented with a text, they may have found the experiment less interesting, leading them to click on the first answer that seemed correct in the questionnaire form, when another answer may have presented itself as ‘more correct’ would they have read that far. Subjects in Group 1 on the other hand, attest to realizing that ‘something was up’ just by seeing the ads, which may point to them having been more engaged with the experiment overall.

Another outcome worth mentioning, is the intervals of each group’s correctly answered questions, which refer to the range between the lowest and highest score on the questionnaire. Group 1 had an interval of 1-6 meaning that the lower score was 1 / 8 (12.5 %) and the highest was 6 / 8 (75%), while Group 2 had an interval of 1-8 meaning that the lower score was 1 / 8 (12.5 %) and the highest was 8 / 8 (100 %). Even though there is no difference in the lowest score, a significant difference appears in the highest score, where in the non-distracted group existed one or more persons who answered all the answers correctly.

Discussion

Ads may influence, but cannot entirely distract the reader

The outcomes derived from the experiments lead to certain conclusions which are worth to be discussed. First, an important observation is that ads do not seem to influence the reader's eye-movement, because they simply ignored them in most cases, or if they looked at them it was for an insignificant amount of time. Thus, their attention cannot be significantly influenced by ads. Once again, it should be mentioned that attention, as mentioned in the introduction according to Anderson (2009) and Wojdynski & Bang (2016), is correlated with the eye-movement.

The results which led to this outcome, have been affected by a number of factors, as some of the participants while admitting that the mock program for detecting facial expressions was credible, they also mentioned that at some point they were aware of the eye-tracking because of the calibration. Though, there was no way we could surpass the eye-tracking calibration step.

Another factor is that many participants claimed to use ad-blockers when surfing the internet. According to some subjects, they find the ads annoying and when they see them, they simply ignore them. Of course, it can also be the other way around, meaning that because they constantly use blockers on websites, they may become more easily distracted, but it seems it does not work this way. In addition to the previous, the ads were not personalized to each subject's interests, resulting in that some subjects may not have found them interesting.

The subject's age group also plays a role in the outcome. Considering that the subjects were between 18-30 years old, that means that they were born and grew up within the age of the internet, so they got used to being exposed to a large amount of advertisements every day, becoming eventually 'immune' to them, meaning that it comes naturally to simply not pay attention to them.

Another claim made by some subjects was that they were not looking at the ads at all. The heatmaps of the subjects who claimed this statement, however, showed that they were looking at the ads even for a small percentage of time (between 1%-5%), an observation which makes it possible to consider that there are some subtle, unconscious eye movements of which humans are not aware of because they might happen multiple times for a very short time, adding up to the total time spent looking at the ads.

Ads influence reader’s short-term information retention ability

Coming down to the questionnaire performance a noticeable difference of 20% was observed between the two Groups, with the ‘non-distracted’ group having a better scoring. This leads to the conclusion that having advertisements all over the page influences the amount of information that the reader is able to retain in the short-term memory. As Anderson (2009, p. 85) states ‘*People can process multiple perceptual modalities at once or execute actions in multiple motor systems at once, but they cannot process multiple things in a single system including central cognition.’*, giving therefore an explanation to why the performance was lower on the ‘distracted’ group. The same conclusion can be derived if the other metrics are taken into consideration. Thus strengthening why H3 and H4 were supported.

A few subjects reported that the text was difficult, especially because English was not their mother tongue. Others stated that it was of medium difficulty. This proves that there was a variation on the subject's perspective over the text. The same pattern was observed on the questions, where some claimed that they were tricky, while others thought that they were medium. Most important, though, is that all of them found the questions on point and related to the text.

Lastly, the average among all participants was 4 / 8 correct answers and the questions which were correctly answered were general questions which focused on the broader meaning and concepts of the article and not on the details of it. This is also supported by Anderson (2009, p. 121) who states *‘Memory for detail is available initially but is forgotten rapidly, whereas memory for meaning is retained’*.

Conclusion

Summarizing, this research showed that ads cannot remarkably influence the reader’s attention while reading an article on a webpage. The same conclusion cannot be deduced for the reader’s short-term information retention, as it shows that ads have a negative effect, diminishing it.

Limitations and Future Work

Throughout conducting this research many limitations and challenges were faced. The software used for the eye-tracking was unstable and hard to work with (in its *supposed* free-to-use version), so a certain degree of bias was introduced from the start.

Talking about future work, a different software or a different method (such as using a highly accurate dedicated camera or equipment that goes on the subjects head, tracking their pupils), should be used in order to improve metrics validity. Preferably, such a method should also do even better at not making the subjects aware of the eye-tracking, to cancel out such bias.

Moreover the experiment might be conducted with more groups (introducing more independent variables), testing the effect of different advertising methods, such as animated (as in with moving elements) ads, or even video ads which could also include sound. Also, the structure and the nature of the ads (different position, shaping) can vary. What is more, the content of the ads can be changed by making a certain test on the subject before the actual experiments in order to figure out its interests and expose him to relevant ads. The previously described potential additions, can be combined with the *within-subject* design, where all participants are exposed to every available condition, meaning that each subject will be exposed to both ‘non-distracting’ and ‘distracting’ websites. This design could make the outcomes of the research more powerful statistically, as individual variation and biases (reading speeds, varying interest in the presented ads, etc.) are removed.

Last, but not least, a more careful sample selection process should be adopted, meaning that the age group should have a wide range and not consist only of young adults, so that more concrete and representative deductions are made. We do see the potential in specifically studying the difference between how much older generations are affected by ads, compared to younger generations that have been brought up around technology.

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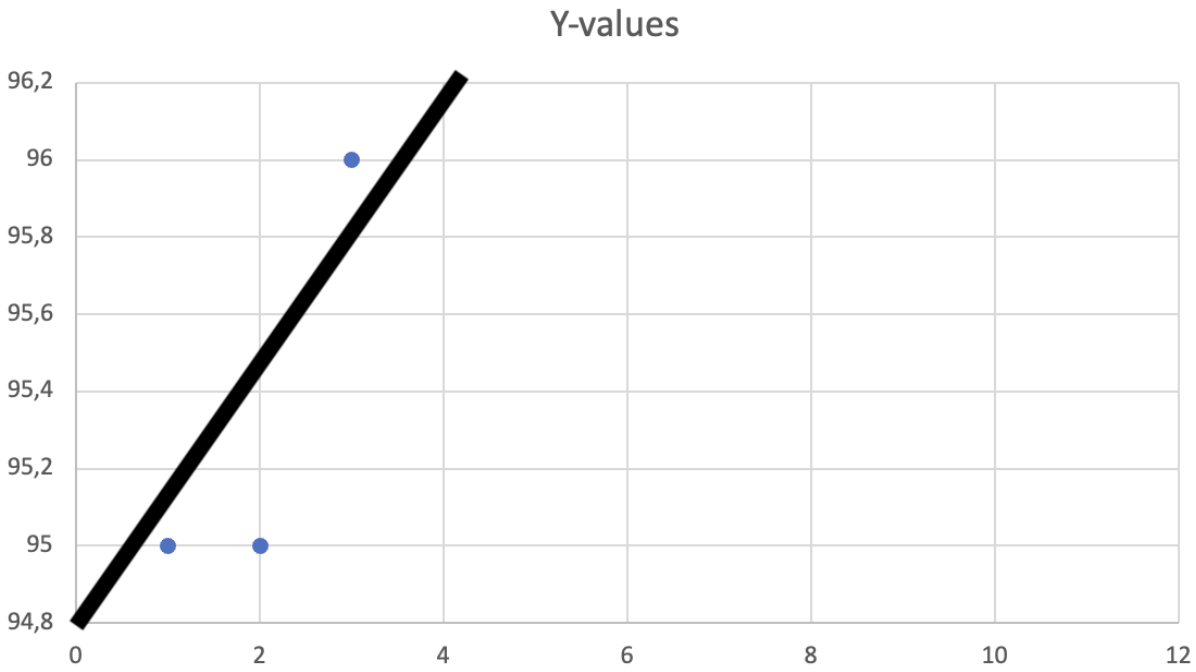
Appendix A

Statistical Analysis

We know that s1 = 95%, s2 = 95% and s3 = 96%, numbers which correspond to the percentage of the total reading time, time which the Group 2's subjects spent looking at the text.

Thus, the following graph can be made:



The graph shows the time spent (y-axis) in relation with each subject (y-axis).
The line is a linear approximation of the function which satisfies the 3 values.

Let y = ax + b (1) be the linear equation

For x = 1 we know that y = 95
Replacing in (1) we get that 95 = a + b and thus a = 95 – b (2)

For x = 3 we know that y = 96
Replacing in (1) we get that 96 = 3a + b and considering (2) we have 96 = 3(95 - b) + b (3)

Simplifying (3) we get b = 94.5 (4) and replacing (4) in (2) we get a = 0.5

Thus, an approximation for the linear equation satisfying the above graph is y = ½x + 94.5 (5)

Having the equation, we can simply replace the values of the subjects whose performance needs to be predicted. The corresponding values are all the discrete values of the interval [4,10].

Substituting in (5) we get:
x = 4 => y = 96.5
x = 5 => y = 97
x = 6 => y = 97.5
x = 7 => y = 98
x = 8 => y = 98.5
x = 9 => y = 99
x = 10 => y = 99.5

Having the approximate time of all subjects we can find the average time spent looking at the text by summing all the values together and dividing by 10.
So, we get an average of 97.2%.

To continue with, we can also find the CI (confidence interval) of the solution.
We choose a p = 0.05, and consequently the confidence level will be 1 – p = 95%.
We will also choose a two-tailed interval, thus $\alpha = p/2 = 0.025$ and the t distribution which is suitable for small datasets (n <= 30).
Using the t-table we can find that the t static in this situation is t = 4.303

The mean for the given dataset (the three values of y we had from the experiments), is 95.3.
The sample variance is where $\sigma = 0.335$, thus $s = \sigma$.

Using the formula

$$CI = \bar{X} \pm Z^* \frac{\sigma}{\sqrt{n}},$$

where σ = s,

we find that CI = 95.3 ± 4.303 * (/) = 95.3 ± ~ 1.437.

Appendix B

Project Time schedule

Week 37	Research methodology
Week 38	Feedback on methodology & preparation for experiment
Week 39	Carry out experiments and begin structuring findings
Week 40	Finalize finding analysis and write the report
Week 41	Hand in report (Wednesday) and prepare the presentation
Week 42	Presentation week