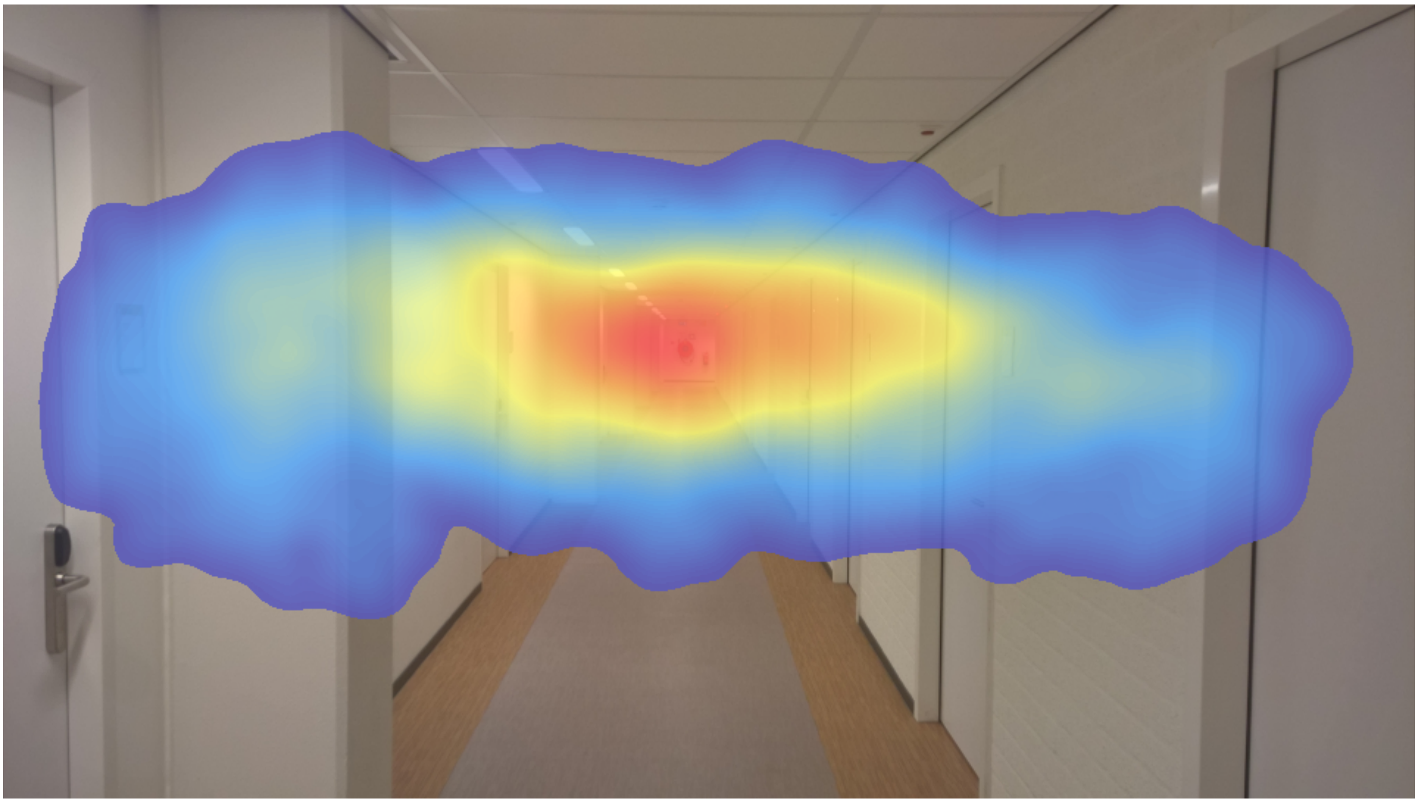
MASTER THESIS:

CAPTURING BANNER BLINDNESS IN A NATURAL ENVIRONMENT

By Nikki Timmers



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Abstract

In this study it was analysed if a mobile eye-tracker can be used to investigate the attention drawing power of a stimulus in a natural environment. This was studied because, it is a promising method to measure the effect of advertisement posters. If people observe advertisements was investigated previously on websites. Benway and Lane (1998) found that subjects avoided looking at these banners and called it banner blindness. Therefore, it was expected that a natural equivalent of banner blindness exist as well.

For this experiment 19 subjects were divided into 2 conditions. The attention drawing power of various targets was measured with a mobile eye-tracker. The subjects assigned to the first condition were searching for the targets. The subjects in the second condition were asked to just look around. The amount of targets that are fixated on, and the time until the target was first fixated on were compared between the two groups.

It turned out it is not possible to determine if the real world equivalent of banner blindness exists. Using the mobile eye-tracker was harder than previously thought for two reasons. First, analysing areas of interest is for practical reasons to difficult. Secondly, the targets often where not fixated on but were detected by the subjects. Furthermore, it was found out that the searching subjects used a wider range of their visual field in the direction of the x-axis. They did not use larger saccades to find the targets than the free viewers.

Introduction

In 2016 €484,404,000 was invested in out-of-home advertisements in the Netherlands (Nielsen Media Research, 2017). Advertising posters are common at bus stops, along the road and in public spaces. But how many people actually look at them? And can it be measured if people observe advertisements in the outside world?

One method to investigate if advertisements are observed could be mobile eye-tracking. Mobile eye-tracking is proven to be useful before in studies with a natural setting. Mostly to study visual attention for various actions such as making a cup of tea (Land, Mennie, & Rusted, 1999), making a sandwich (Hayhoe, Shrivastava, Mruczek, Pelz, 2003), driving a car (Shinoda, Hayhoe, & Shrivastava, 2001), or decision making in the supermarket (Gidlöf, Wallin, Dewhurst, & Holmqvist, 2013). Therefore, we expect that it is possible to study the attention drawing power of advertisements in a natural setting as well.

An eye-tracker is a device that measures where someone's eye is fixating on. The eye is filmed with a camera and it is detected where the pupil is directed to. With calibration the exact location of the fixation is determined. For most remote eye-trackers this is a point on a computer screen. Mobile eye-trackers are devices that have cameras mounted to the head using glasses or a helmet. As a result subject are able to walk around freely. It does not solely contain the camera that films the eye, a mobile eye-tracker also has a scene camera. A scene camera is camera located just above the eyes that records the scenery. Subsequently, the fixations of the subject are displayed in the image of the scene camera (Holmqvist et al., 2011).

The direction where someone is looking is a good estimator of the place where one's attention is, since attention is needed to direct one's eye movement. A study of Rizzolatti, Riggio, Dascola, and Umiltá (1987) showed that a stimuli that appeared on unattended locations are responded to slower than stimuli appearing on attended locations. Furthermore, Hoffman and Subramaniam (1995) found that subjects had difficulty moving their eye to one location while cued to attend another. But how is that attention controlled?

There are many theories about visual attention, of which the division between bottom-up and top-down is widely used. Bottom-up factors come from the stimulus and top-down factors from the person (Pieters & Wedel, 2004). Bottom-up attention makes sure that elements that pop-out are actually noticed and therefore can prevent one from danger. Elements are most salience when their form, colour or orientation differ from their surroundings (Theeuwes, 1992).Therefore, a gorilla is less salient in a zoo compared to the streets of a residential area. Simultaneously bottom-up or exogenous attention ensures that not all detected stimuli are noticed, which spares a lot of energy. Top-down or endogenous attention is coming from higher-level cognition, it makes sure one can focus on a particular task and is not disturbed by the rest of the external world. Only stimuli that are important to provide the goal are selected. This is convenient when one is reading a book. Bottom-up and top-down attention interplay when one is reading a book and a gorilla comes into the room.

Advertisers are doomed to use bottom-up attention to transfer the message to the uninterested receiver. People are not looking out for advertisements in everyday life. Therefore, the salience of the ad must ensure that people unintentionally fixate on them.

The attention paid to advertisements is studied before, mainly of advertisements on internet websites. Studies about online advertisements are practical study objects since it is a natural environment that can easily be investigated as a laboratory study. Furthermore, 82.1% of the population in the Netherlands uses internet daily (Centraal Bureau voor de Statistiek, 2016). Therefore, the attendance to internet advertisements are very common for most of the population.

When studying internet advertisements, Benway and Lane (1998) found out that subjects did not click on banners while searching for specific information on websites, even though these banners could actually help finding the information faster. They concluded the banners were not perceived and introduced the term ‘banner blindness’. Next to this, the study of Benway (1998) stated that only 20% of the subjects could recall if a banner was present at the website. Surprisingly, Burke, Hornof, Nilsen and Gorman (2005) found that search performance decreased when advertisements were present. But when they tracked the eye movements, the subjects avoided fixating on the advertisements and on places ads were expected. Most fixations on the advertisements occurred in the first eye movements, before the locations of the advertisements had been set. Another study by Hervert, Guérard, Tremblay, and Chrourou (2011) showed the same results: 82% of the subjects fixated at least once on an advertisement, yet 63.3% of the banners was not fixated on by the participants. On top of that Rohrer and Boyd (2004) found that their subjects developed a negative attitude towards intrusive advertising.

Originally the aim of the present study was to investigate if there exists an equivalent of banner blindness in a natural environment. However, a few problems arose. First, no one has absolute control of what advertising posters are visible for the subjects in a natural environment. As a consequence, there is no regulation of the salience, size and frequency of the posters on the wall. Obviously, there is no influence of the experimenter on when the posters are switched or taken down, and this is problematic when a study is not executed in one day but takes a couple of weeks. Secondly, it is hard to control the environment around the advertising posters. The crowds of people can vary a lot over time. Thirdly, the depth of the hallways contributes to the interpretation of the eye-tracking data. When a poster is far away a fixation on the poster will contain a different content than when it is nearby. And at last, it is unclear from how far one has really seen the content of the poster, and how this is effected by the size of the poster. To overcome these problems a half laboratory study is implied, whereby the natural environment is an office and the overall salience of similar simple targets is measured.

The aim of this study was to analyse if a mobile eye-tracker can be used to investigate the attention drawing power of a stimulus in a natural environment. For this purpose, 20 subjects were randomly assigned to one of two conditions and conducted two experiments. The first experiment was a computer task to measure the subjects search performance. This is to verify if the two conditions contain subjects with the same search abilities. The second experiment was to investigate the attention drawing power of the various targets. All subjects walked a route while wearing a mobile eye-tracker. The subjects assigned to the first condition were the visual searchers and were asked to search for specific targets, pink hart shaped sticky notes. In this way we established the maximal drawing power of the search goal. The subjects in the second condition were the free viewers and were asked to just look around. The amount of targets that are fixated on, and the time until the target is first fixated on were compared between the two groups. With this the attention drawing power of the targets is measured.

The main question of this study is if it is possible to measure the attention drawing power of a target with a mobile eye-tracker? If this is possible it is hypothesized that a natural equivalent of banner blindness exists. Therefore, subjects who searched for the targets would fixate on more targets and fixate on them sooner. The last hypothesis was to map the behaviour of the two conditions and stated that searching subjects fixated in a wider range of there visual field than non-searching subjects. Furthermore, subjects in the search conditions use larger saccades to scan their surroundings than subjects who were free viewing.

Methods

Participants and Design

The twenty participants that took part in the experiment were personally approached by the researcher and participated voluntarily. One participant was removed from analysis because of a technical error. We included 2 males and 17 females, with a mean age of 23 years old (SD=1.97), see table 1. All had normal or corrected to normal vision but did not wear glasses since then the eye-tracker glasses would not fit. For a between-subjects design the participants were randomly assigned to one of two conditions: 1) the visual search condition, where participants had to search for the targets or 2) the free viewing condition, which had no additional instructions. 10 participants were included in the visual search condition and 9 participants in the free viewing condition.

Materials

The Tobii Pro Glasses 2 was used to track the eye movements of the participants. To process the eye-tracking data Tobii Pro lab software was used. The computer search task was programmed and executed in Opensesame. This task was displayed on a laptop with a 15.6 inch screen.

Procedure

Subject characteristics

All participants were informed about the experiment and signed the informed consent. A photograph of the face was made to capture facial features as eye colour and eye size. The body height, pupillary distance and head size were measured. Four questions were asked concerning there familiarity with the building, having an eye disease, having reduced vision, and wearing contact lenses.

Eye-tracker measurement

The eye-tracker glasses were adjusted to the position, while making sure that the pupils were clearly visible for the eye-camera and the eye-tracker was calibrated on a single point held on arm-length distance. A walking route was explained to the participant. The route was the same for all participants and leads past office rooms and laboratories. This route was chosen since the wall decorations did not change over

Figure 1. Target from the eye-tracking measurement.

the time of the experiment, and the amount of people passing by was constant during the day. When the recording of the eye-tracker started, the participant had to look at 6 dots on an A3 sheet of graph paper with squares of 0.5 cm. This was used to measure the accuracy and precision of the eye-trackers. The participant was put on a headphone, with music that was playing is around 90 beats per minute (BPM). The subject was instructed to walk the explained route on the rhythm of the music. By doing so all the participants walked roughly the same speed, and had the opportunity to see the targets at the same time. Fifteen targets were placed on the walls of the route. The targets were pink heart shaped sticky notes (see figure 1). The participants in the visual search condition (condition 1) were instructed to search for the targets. The participants in the free viewing condition (condition 2) were not aware that the targets were part of the experiment. Halfway and at the end of the route the accuracy and precision was measured again by looking at 6 dots on an A3 sheet of graph paper.

Computer search task

Directly after the eye tracker measurement, a computer search task was made to check if both participant groups contained participants with the same search abilities, since otherwise, an effect in this eye-tracker study could be due to the group differences. The goal of the computer search task was to find a vertical gabor blob among 24 slightly tilted gabor blobs, see figure 2. There were 50 stimuli in total, but only half of the stimuli contained a vertical gabor blob. When the target was found, the participant was instructed to press the "p"-key, and when the target was not found the subject was instructed to press the "q"-key. The task started with 4 test trials, after which feedback was given on the computer screen.

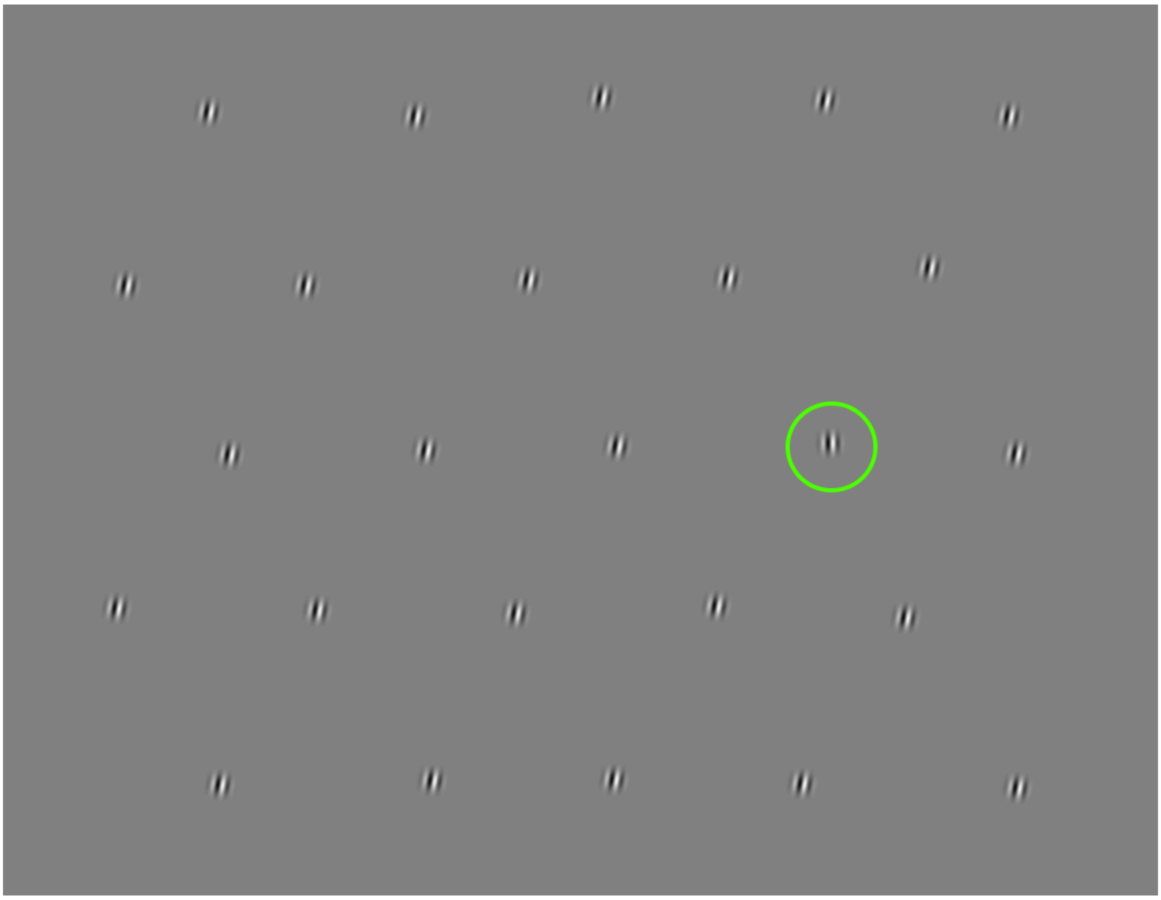

Figure 2. Computer search task stimuli with a target.

Data-analysis

Eye-tracker measurement

All first fixations on a target were coded as a separate events using Tobii Pro lab, see figure 3. Furthermore, the beginning and end of the walk were indicated, as well as the beginning and end of the accuracy and precision task in the middle of the walk.

The attention drawing power of the targets was measured with T_{50}. T_{50} is the moment in time in ms that 50% of the participants has fixated on the target (Hooge & Camps, 2013). The T_{50} of the participants in the search-condition and the walk-condition are combined and compared for every target separately. An independent samples t-test was used to compare the T_{50} of the search condition (condition 1) and the walk condition (condition 2) (using an α of .05).

Figure 3. Screenshot of data obtained by Tobii pro glasses 2. Red circle indicates the fixation point of the subject. Left of the fixation point a target is visible.

Computer search task

The correctness of the response and the response time were measured. A Mann-Whitney U Test was used to compare the amount of correct responses and the mean response time between the search condition and the free view condition (using an α of .05).

Dispersion in the visual field

To compare the dispersion in the visual field of the two conditions heat maps were compared. The heat maps consisted of all the fixations of the participants in one of the two conditions. Thereafter, the mean distance from the mean was measured in the X direction. With an independent samples t-test these means were compared between condition 1 and condition 2.

Saccades

The saccades of the participants were obtained by measuring the distance between two fixations in pixels. With an independent samples t-test the mean saccade length from the two conditions were compared.

Results

Demographics

The searching group and the free viewing group consisted around the same amount of subjects and were of the same age, table 1, t(17)=.08, *p=.934*. The percentage females was high in both groups and the subjects in the searching condition were marginally shorter than the free viewing subjects, t(17)=-2.08, *p=.053*. Furthermore, the head size of the searching groups was significant smaller than the head size of the free viewing group t(17)=-2.424, *p<.05*. The pupillary distance did not differ between the two groups t(17)=-.096, *p=.924.*

Table 1.
Demographics

	Visual search condition (1)		Free view condition (2)	
N	10		9	
Age	23	(2.21)	23	(1.79)
Female (%)	90%		88,89%	
Body height	175	(6.80)	181	(6.03)
Head size	56.1	(1.45)	57.61	(1.24)
Pupillary distance	6.25	(.72)	6.28	(.51)
Contact lenses (%)	20%		22.22%	

Note: For all data the mean (SD) is reported, with the exception of: N, Female, and Contact lenses.

Computer search task

To determine if the participants of the two conditions had the same search qualities, the subjects executed the gabor blob computer task. Their reaction time and the accuracy of their responses were measured. To compare the results of the two groups a Mann-Whitney U Test was used since the results were not normally distributed. As seen in table 2, the searching group and the free viewing group did not significantly differ in the accuracy of their responses, U=40.50, *p=.712*.

To compare the reaction time between the two conditions, the reaction times of the trials with a correct response were used. Since the reaction time of all trials was skewed the median was used to determine the reaction time per participant. The U test revealed that the overall reaction time in ms of the visual search group (M=8879.45, SD=5674.34) showed no significant difference with the free viewing group (M=8714.67, SD=4021.75); U=39.00, *p=.624*. Figure 4 shows the reaction times between the two conditions when the target was present and when it was absent. The reaction time of the trials with a present target did not significantly differ between the visual searchers and the free viewers, U=41.00, *p=.744*. When the target was absent the search group and the free view group did not differ either; U=43.00, *p=.870*, see table 2.

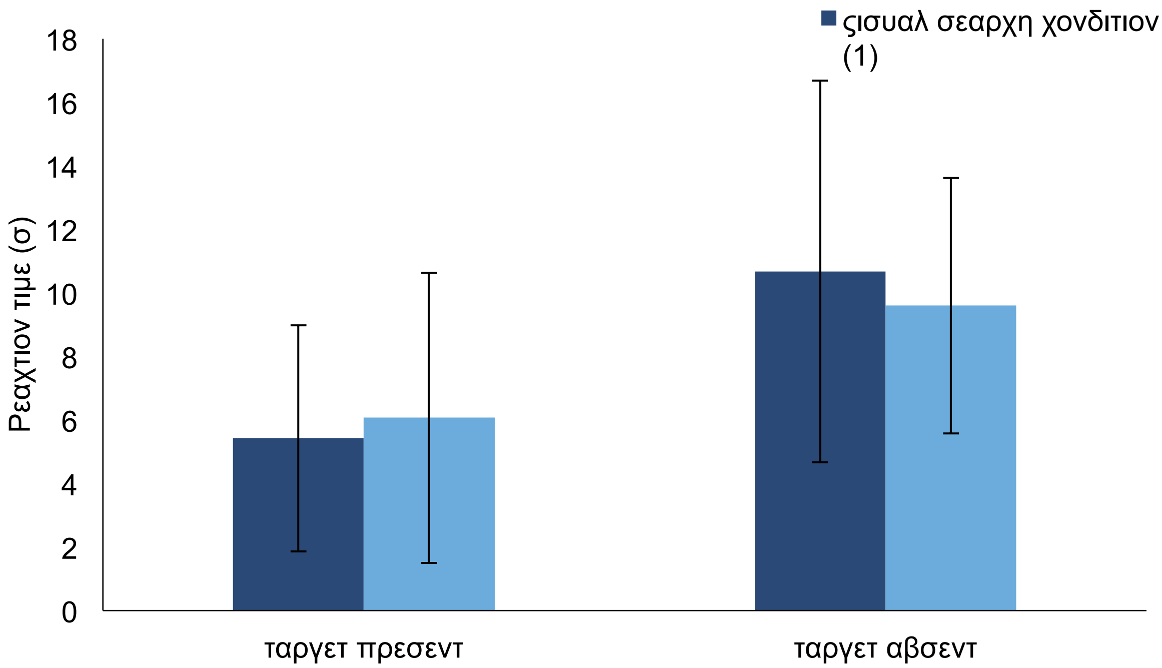

Figure 4. Mean reaction time in the computer search task for the trials when the target was present and when the target was absent. Error bars denote one standard deviation around the mean.

Table 2.
Mean and standard deviation of the results on the computer and mobile eye-tracker task.

	Search condition (1)		Free view condition (2)	
Computer task				
Accuracy responses (%)	83%	(12.34)	84%	(3.90)
Reaction time overall (ms)	8879.45	(5674.34)	8714.67	(4021.75)
Reaction time target present (ms)	5421.40	(3564.44)	6070.89	(4575.10)
Reaction time target absent (ms)	10672.15	(6006.05)	9597.39	(4021.11)
Mobile eye-tracker				
Dispersion in the visual field (pixels)	310.11	(29.01)	264.75	(52.72)
Length of the saccades (pixels)	444.37	(56.81)	359.97	(104.38)

Note: For all data the mean (SD) is reported.

Attention drawing power

To measure if a natural equivalent of banner blindness exists the first fixation time on the targets should be compared between visual searcher and free viewers. However, when coding the fixations of the participants a major problem arose. There was not always a visible fixation on the target when the subjects in the search condition reported an observation. Therefore, it was impossible to determine if and when the subjects in the free viewing group had fixated on the targets and subsequently, it was not possible to confirm or deny if an equivalent banner blindness in a natural environment exists.

Dispersion in the visual field

In order to map the behaviour of the subjects the heat maps of the free view and the search condition, figure 5, were observed. It was noticed that the searching participants used a wider range in the x-axis of their visual field than the participants in the free viewing group.

To statistical test this observation the mean fixation point on the x-axis was measured for all subjects separately. Subsequently, the means distance from the mean was measured for all subjects. This measurement was compared between the conditions. This showed that the searching subjects (M=310.11, SD=29.01) used a significant wider range of their visual field than the subjects in the free viewing condition (M=264.75, SD=52.72); t(12.15)=2.29, *p<.05* (table 2).

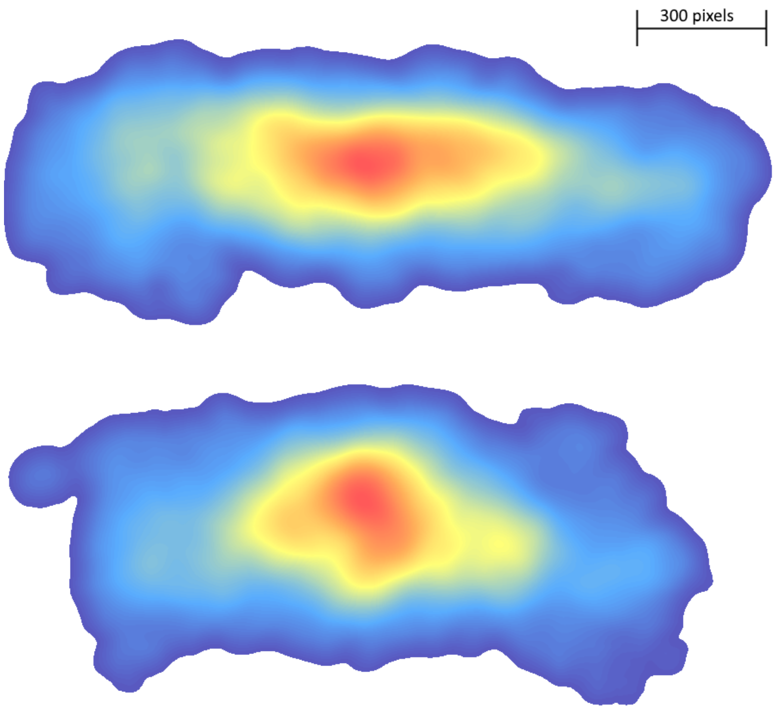

Figure 5. Heat maps of all the fixations of all the subjects combined in the visual search condition (top) and the free viewing condition (bottom).

Saccades
To further examine the behaviour of the participants the saccade length between the two groups were compared. The x and y coordinates of the fixations were used to measure the length of the saccades. With use of the Pythagorean theorem the distance between two pair of x and y coordinates was measured in pixels. Since the deviation of the saccades per participant was skewed to the right the median was used to obtain one saccade length per subject. The visual searching subjects (M=444.37, SD=56.81) did not have larger saccades than the free viewing subjects (M=359.97, SD=104.38); t(12.07)=2.16, *p=.052*, see table 2.

Discussion

In this study the aim was to analyse if a mobile eye-tracker can be used to investigate the attention drawing power of a stimulus in a natural environment. Therefore, half of the participants got a visual search task while the other half were free viewers. All subjects walked around an office environment wearing a mobile eye-trackers to measure their first fixation time on different targets. However, when coding the data it was noticed that subjects in the visual search condition, often reported an observation while the fixation was not near the target. This created a problem in determining if free viewers had looked at the target. Since they did not know the targets belonged to the experiment they could not orally reported that they had seen one.

The absence of a visible fixation on the target when an observation is reported, has various explanations. First of all, when a fixation is made on an object with a greater distance the measurement is less accurate compared to fixations on targets nearby. Since a small movement of the pupil covers a large area on a great distance but also covers a smaller area at a shorter distance. In this study all targets are perceived on different distances, making it impossible to correct using a standard error margin. This is in contrast to the studies who research visual attention in a natural setting with a mobile eye-tracker before. All the fixations needed for those actions were made close to the subject, therefore there was no great difference in accuracy during the task (Gidlöf, Wallin, Dewhurst, & Holmqvist, 2013; Hayhoe, Shrivastava, Mruczek, Pelz, 2003; Land & McLeod, 1999; Shinoda, Hayhoe, & Shrivastava, 2001). Secondly, the target has to be very salience to be visible on the data of the scene camera. When a colour like yellow is used there is not enough contrast with the walls to detect the target from the video. However, when a bright colour like pink is used, subjects do not need to fixate on the target. It can already be located in their peripheral field. Thirdly, a mobile eye-tracker is not that accurate overall, compared to remote eye-trackers, especially when the target used is not that big. Fourthly, the scene camera often could not mange when the subject made quick head movements. For a couple of seconds the video became a fixed blurry image. Because of these problems it can be stated it is not possible yet to investigate the salience of a stimulus in a natural environment with a mobile eye-tracker with this set up.

Due to these problems, it was concluded that it is impossible to measure the attention drawing power of a target with a mobile eye-tracker. Furthermore, this caused that the second hypothesis could not be confirmed or denied. It was hypothesized that a natural equivalent of banner blindness exists. Subjects who searched for the targets would fixate on more targets and fixated on them sooner than free viewing subjects. This was however, not measurable.

At last it was expected that subjects in the searching condition would fixate in a wide range of there visual field and would use larger saccades to scan their surroundings. The results show that searching subjects indeed used a significant wider range of their visual field in the direction of the x-axis. However, the searching subjects did not use larger saccades than the subjects in the free viewing condition. These results indicate that people with a search assignment make more fixations in the area a target can appear. But do not use larger saccades to scan that area.

Besides that it was impossible to confirm if a subject in the free view condition fixated on the targets, more limitations arose. First, especially the subjects in the visual search condition had a great amount of workload. They had to walk on the rhythm of the music, had to search for the targets, and had to report when a target was observed, while it was the first time they wore a mobile eye-tracker. Therefore, some subjects initially forgot to walk on the rhythm of the music or search for the targets. Furthermore, the targets in this study are all exactly the same. Because of this some subjects in the free view condition recognised the targets as part of the study. Therefore, the targets became more salience than they already were.

For further research it is recommended to use less depth in the environment. The difference in accuracy as a result of targets on various depths is the hardest problem to concur. This could be achieved by designing the study more like the equivalent on internet websites. Where subjects stand multiple times in front of an information board with information like timetables and opening hours on white sheets and one advertising poster. Again half of the participants could search for the poster and the other half does not. The time difference between the two groups could be used as a measurement of salience.

Concluding, present-day mobile eye-trackers cannot be effectively used for a difficult experimental problem with many varying distances between the subject and the small search target. Therefore, it cannot be said if banner blindness also occurs in a natural environment.

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