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Counteracting racial discrimination through attention direction based on subtle visual cues

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Abstract

Human decision making has always been an interesting subject to try to understand and be able to affect. With fast development of eye trackers and toolboxes associated with the eye trackers it has opened possibilities of areas it can be applied to. In this thesis, we have applied the eye tracking technologies and with help of subtle stimuli to try counteracting racial discrimination on CVs as they are being assessed.

To investigate if it's possible to contract racial discrimination on CVs we designed a subtle gaze direction prototype that actively collects eye tracker data and makes subtle stimuli on non-discriminative areas of the CV. In conclusion, people eye movement are prone to being affected by the subtle cue while their judgment is not affected.

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Sammanfattning

Mänsklig beslutsfattning har alltid varit ett intressant ämne att försöka förstå och påverka. Med snabb utveckling av ögonspårare och verktyg associerat till ögonspårare så har det öppnat möjligheten för områden detta kan appliceras. I denna avhandling har vi applicerat ögonspårningsteknologi med hjälp av subtila stimuli för att försöka motverka rasdiskriminering på CVn under tiden de granskas.

För att undersöka om det är möjligt att motverka rasdiskriminering på CVn, så har vi designat en ”subtle gaze direction prototype” som aktivt hämtar ögonspårningsdata och gör subtila stimuli på icke-diskriminerande platser på ett CV. Sammanfattningsvis är människors ögonrörelse benägna att påverkas av subtila stimuli, medan deras omdöme inte är det.

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We would like to thank Sayaka Torngren at Malmö University for giving us job applications for our practical experiment on our SGD prototype.

Table of Content

Abbreviations and Definitions

SGD: Subtle Gaze Direction

CV: Curriculum Vitae (job application)

AOI: Area of Interest

PCCR: Pupil Center Corneal Reflection

ADCS: Active Display Coordinate system

1 Introduction

Ethnic discrimination is pervasive in society. A recently started (2021) research project funded by the Swedish Science Foundation investigates the mechanisms and processes of ethnic and racial discrimination in hiring through examining employment decisions using eye-tracking in combination with dialogue and survey in an experimental setting [1]. University West is a project partner with a focus on investigating how to objectively measure racial bias and how to potentially reduce it by intervening in how documents are literally perceived.

1.1 Background

Human decision making has always been an interesting subject to try to influence. First time the idea of using subtle cues to influence decision making was introduced more than 30 years ago through Mark Wieser [2]. The idea was that some technology in the background, that wasn't visible for the user, would influence and change the decision making of the user.

Through the modern technologies of eye tracking awoke the idea of trying to influence and reduce societal problems such as racial discrimination. One area of racial discrimination is when applying for work and therefore we want to reduce the impact of racial bias towards different applicants, by using Subtle Gaze Direction (SGD).

Bailey describes SGD as:

> Subtle gaze direction exploits the fact that our peripheral vision has very poor acuity compared to our foveal vision. By presenting brief, subtle modulations to the peripheral regions of the field of view, the technique presented here draws the viewer's foveal vision to the modulated region. Additionally, by monitoring saccadic velocity and exploiting the visual phenomenon of saccadic masking, modulation is automatically terminated before the viewer's foveal vision enters the modulated region. Hence, the viewer is never actually allowed to scrutinize the stimuli that attracted her gaze [4].

Our idea is to try to mitigate and measure the effect of the racial discrimination and the effect our counteractive SGD prototype have on the participants in making them change eye focus. Techniques and equipment we are using in the project is a laptop, a Tobii eye tracker, and our SGD prototype. Tobii eye tracker provides the SGD prototype with real time data which make it possible to apply a dynamic SGD after the participants eye focus. The SGD is being deployed on the laptop screen for the participants in the test.

1.2 Research goal and Hypothesis

The goal of this thesis is to examine if a Subtle Gaze Direction (SGD) prototype can guide the attention of a user by directing their gaze focus from one area of interest (AOI) to another. This will be done by making barely visible stimuli on the screen with, for example, flashes or blurring to draw away attention from parts that are prone to discrimination and focus on more objective relevant parts of a job application.

The working hypothesis is that people are prone to be affected by carefully designed subtle cues: at low levels of perception by changing their eye movement patterns; at higher levels by judging what they are looking at differently.

1.3 Research questions

The research questions in this thesis are:

1. How do we counteract racial discrimination through eye tracking?
2. Can we through subtle stimuli make people pay more attention to non-discriminative areas?
3. Can subtle stimuli speed up the assessment of the job application

1.4 Limiting Factors

- Tobii Pro Nano is used as a screen-based eye tracker with a max screen size of 24”
- Only one SGD-method was implemented and tested
- The SGD-prototype was only tested in a controlled experiment with a specially designed job application

2 Related work

This chapter will go over the literature on three areas: discrimination, subtle gaze direction and eye tracking. All these areas will be reviewed on what has been done before and how that is relevant to this thesis.

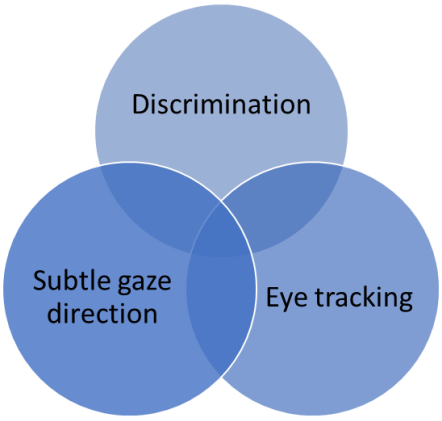

Figure 2.1. Venn diagram showing the related areas for this thesis

2.1 Discrimination

When reading job applications, it's shown that the reader processes the job application in the same way but spends less time on young people with a foreign background. Lahey & Oxley [3] made an experiment where they randomly varied the content of each job application based on race, gender, age between 36 to 76 and socioeconomic status. Lahey & Oxley then asked students to rate the job application on a scale of 1-7. While the students were reviewing the job application, they used an eye tracker to track for how long and where they were looking. The result was that Lahey & Oxley found out that young foreign people were less preferred.

Pager & Western, [4] describe the problem of racial discrimination on job applications. Pager & Western, did an experiment by sending in work applications with the same work experiments but with different names and colors of skin and the photo in the work application. The experiment was done in Milwaukee and New York. The result of the study showed that non-black applicants had twice the chance of getting a call back about the work applications unlike the applications with black skin color.

Discrimination is a wide occurring problem in society today. In the study [5] they look at how discrimination has changed through the years and wondered if the world has become less racial discriminatory. The study compared how many newly born children had one parent that was not from the country of birth, that would say mixed race. Goal of the study was to compare if the amount of newly born with mixed race is rising from the 1970 and if it is a consequence of a more open society on mixed race relationships. The study was conducted in nine different countries. The result showed that it was more common today with the birth of mixed raced children than 40 years prior which can point at les discrimination today than in the past.

With our SGD prototype, we want to try keeping the reader intrigued in the job applications, that has a person with a foreign background, for the same amount of time as people that come from the same nation. In today's society racial discrimination is a big problem and through the reading of the papers [4,5] it has given us a bigger understanding of racial discrimination in the society and how it was in the past.

2.2 Eye tracking

Nyström et al. [6] "A toolbox for creating PsychToolbox and Psychopy experiments with Tobii eye trackers" is describing how their library connects Tobii eye tracker with python code through PsychToolbox. In the paper they describe how the toolboxes for PsychoPy provide a simple way to conduct eye tracking to experiments using Tobii eye trackers. Our research is an improvement of this research because it widens the scope of which this toolbox can be used.

In [7], Lukander explains how to use human eye tracking and interaction with applications. He describes how to get the data and focus from the eyes on the screen through filming the iris. Lukander, tracks the focus of the iris through visual placing six dots on the eye and sees how the iris distance to the dots change. Through the change in distance to the dots they can determine which directions the glance is on the screen.

Unlike the earlier paper [7] the third paper [8] describes the different techniques that are used to track the eyes glance. The main goal of the paper is to describe when different techniques are best suited and how the technology has progressed from earlier techniques. The latest technique is "Pupil Center Corneal Reflection" (PCCR). The technique is centralizing the iris using two rectangular meshes that an algorithm calculates the eye gaze.

This paper [6] is important to our project because we will use the library to be able to gather data from Tobii eye tracker and to write a program in Python that can give subtle cues to change focus of the reader. The other papers [7,8] are important to our work because it gives us a knowledge of how different eye tracking techniques work. The papers [7,8] also describe when different eye tacking techniques are better suited and pros/cons with the different eye tracking methods.

2.3 Subtle gaze direction

Bailey et al. [9] describe different techniques that can be used to give subtle gaze and why some subtle gaze is better than others in certain situations. The goal of the paper is to give a wider knowledge of different techniques in subtle gaze and how to implement them. In the paper [10] of Steve Grogorick he describes how subtle gaze guidance can be used in an immersive environment. With subtle gaze Grogorick is trying to see how subtle gaze is affecting the ability to select certain objects quicker in an environment full of different objects. Grogorick uses a head worn display and eye tracker to conduct his experiments with eye tracking and subtle gaze. The paper concludes that there is a difference with subtle gaze and the result was visible for all participants to a various extent.

Reynold et al. [11] investigated if there were any differences in results in short time memory using subtle gaze versus none. Reynold concluded that there was a difference in the result with subtle gaze, increasing the short time memory. The value of the paper [11] in our work is that it shows that short time memory is affected and can be helpful in our work with preventing racial bias and increasing the short time memory.

Dostal, Jakub et al. [12] used four different display techniques to make subtle gaze on. The different environments were: FreezeFrame, PixMap, WindowMap and Aura. Dostal, Jakub helps us in giving us a wider understanding of different techniques that can be used and the limitations of them.

The importance of [9] to our work is to give us knowledge of the best suited subtle gaze for our work. In paper [11,10] they described the effect subtle gaze had on the participants regarding the time it took to do the experiment and the effect on the memory of the participants to remember the gazed objects. Dostal, Jakub et al. [12] describes different display techniques that can be helpful for our work with displaying subtle gaze.

3 Technology and SGD design

This chapter presents the main different technologies used in the paper to reach the goals of the research questions. The main technologies used in the paper is an eye tracker and software to be able to present subtle cues on the screen.

3.1 Tobii Eye Tracker

The eye tracker used in this thesis is a Tobii Eye Tracker Pro Nano, which is a screen-based eye tracker. The eye tracker captures gaze data at 60 Hz on a screen size up to 24" (the gaze point will not be as accurate on larger screens in the corners) and uses a technique called "Pupil Center Corneal Reflection" (see chapter 3.2).

For this thesis, the output that is relevant are:

- Timestamp
- Active Display Coordinate System (ADCS)

3.1.1 Timestamp

The timestamp output is used to time which specific events are happening (as key pressing and stimuli being presented on the screen) during the experiment and be related to the recorded data. The eye tracker is using two different timestamp variables "device_time_stamp" and "system_time_stamp". The former is the timestamp for the specific eye tracker in use and the latter is the system on which the eye tracker is being used.

3.1.2 Active Display Coordinate System

ADCS is the coordinate system of the display in which are being used with the eye tracker excluding the display frame [13]. The coordinates (0, 0) are in the upper left corner and (1, 1) is the lower right corner of the display.

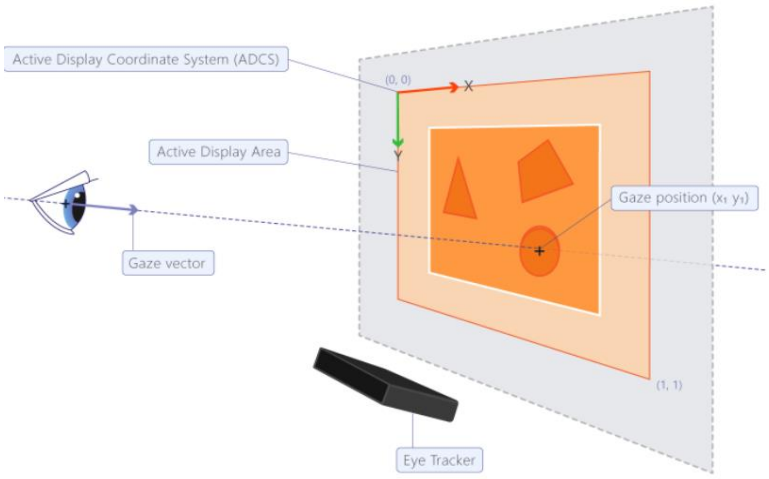

Figure 3.1 Active Display Coordinate system

3.2 Scripting with Psychopy

Psychopy was created as an application that can run experiments for behavioral science with exact timing control of stimuli. Psychopy is used together with the tobii eye tracker to present the stimuli on the screen for the user to see. Psychopy gives users the opportunity to follow experiment frame-by-frame to control the monitoring of the experiment. Through the ability of choosing which version to run, Psychopy makes it so that older programs don't need to be obsolete due to newer versions not being compatible with older ones. The ability to monitor the experiment step-by-step may not be as reliable in older versions to the contrary to newer ones.

It also provides the choice to use python as script for flexibility, instead of only using Tobii eye tracker functionalities. Functionalities provided in Psychopy ranges from a variety of stimuli, support for python 3 and a graphical user interface.

3.2.1 Subtle gaze direction

For designing the subtle cue, three attributes are interesting: the size, shape, and opacity. These attributes have been tested in similar experiments [14] and are easy to manipulate in Psychopy.

The cue size determines how big the cue is. In [14], they suggested that increasing the size of the cue will improve the visual guidance, although reducing the subtleness of the cue. Having that said, it is important to design cues that have a good balance between subtleness and size.

The opacity attribute is how transparent the subtle cue is on a scale of 0-1. The idea is to increase or decrease the opacity attribute depending on if the user focuses their gaze on the cue or not.

The cues shape determines how the cue will look on the screen and [14] suggests that the shape of the cue does not affect its effectiveness.

3.2.1.1 SGD prototype design

When designing the shape, we thought it would be a good idea to go for a rectangular shape, since we want the participants to focus on the objective text-part of the job application. With the rectangular shape, we can make the rectangle enclose a paragraph, almost as highlighting it.

To trigger the SGD, we took the coordinates around the name and picture of the applicants and made that a trigger zone (see figure 2.2)

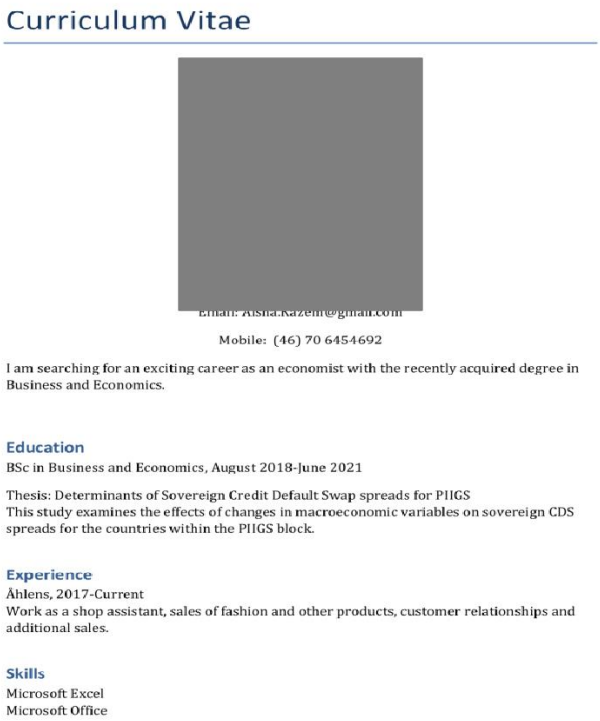

Figure 3.2 trigger area for the stimuli.

To trigger the SGD, we used the latest sample from the ADCS from the eye tracker and used those coordinates for a completely transparent circle. Since the coordinates of the circle are in the middle, its size does not matter. When the circles coordinates are inside the trigger zone, the SGD is triggered.

The value of the opacity of the SGD starts at 0,005 and increases the longer the user looks at the trigger zone. To see how different values look, see figure 2.3. To get the opacity value of 0,02, the user had to look at the zone trigger for 0.933 seconds and to get an opacity value of 0,06, the user had to look for 2,6 seconds.

Figure 3.3 different opacity values on the SGD. Left image had a value of 0,02 and the right 0,06

As soon as the user looks away from the zone trigger, the SGD is no longer being presented on the screen and its opacity value is reset.

To see a video example of how the SGD prototype works with a visible gaze circle, you can click the link below.

https://www.youtube.com/watch?v=2MtWTsQ8MIU&ab_channel=ThomasGreen

4 Research methodology

When doing research, there are many ways one can go about designing the research methodology. This chapter will present the methodologies that are being used in this thesis.

4.1 Quantitative research

Quantitative research explains a phenomenon by collecting numerical data and analyzing that data based on mathematical methods [15]. There may be phenomena that one would want to examine, without it necessarily producing quantitative data. For example, in [3], they asked the student what they thought about the job application. As this question per se didn't produce any quantitative data, they asked the students to rate the application on a scale of 1-7, and therefore made numeric data that can be collected and analyzed. Therefore, surveys are often used when doing quantitative research.

4.2 Qualitative research

Qualitative research is a non-numerical approach. It is used to study a phenomenon by gathering information and getting an understanding about it instead of measuring it. These phenomena can be things like opinions, political views and so on and are also more complex to analyze. Case study and Actions research are two methods used to collect qualitative data.

4.3 Literature study

To find information for the thesis and get a better understanding of the research area, a literature study was done. The areas which were covered are Discrimination, Eye Tracking and Subtle Gaze Direction. Google Scholar and Institute of Electrical and Electronics Engineers (IEEE) were the databases that were used in the literature study. Papers were examined to evaluate their relevance for this thesis. The relevant ones are presented in the Related work chapter (see chapter 3).

4.4 Mixed method approach

This research approach uses the combination of quantitative and qualitative research to get a better understanding of a problem. This can be done by using the quantitative approach to collect and analyze numeric data to draw a basic understanding of the phenomenon, and then use the qualitative approach to put the data in a bigger picture.

4.5 Our method

In this thesis we developed our SGD prototype with the eye tracker Tobii Pro Nano. We did this with an iterative design process with three iterations. The first was a low fidelity prototype that just outputs data from the eye tracker. In this iteration there were just a blank screen with no job application that output shapes that were moving around or blinking on the screen.

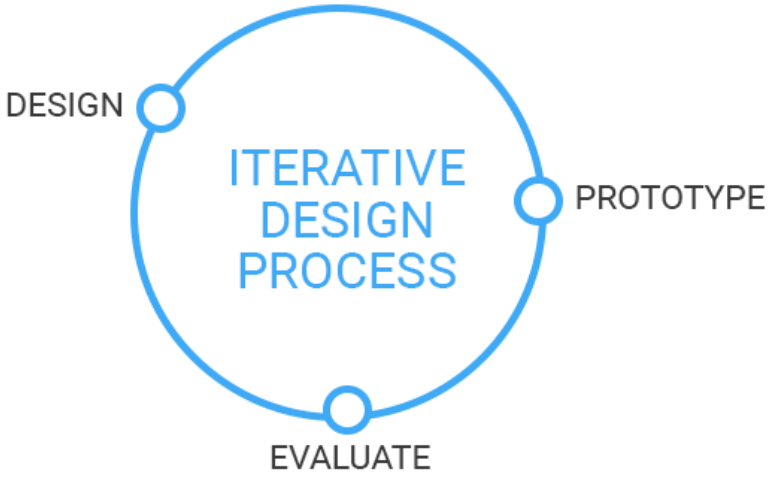

Figure 4.1 Iterative design process

In the second iteration, the prototype incremented so that there was static subtle guidance on the job applications. In the first two iterations, there was only a quantitative approach by getting raw data from the eye tracker. To evaluate the prototypes, we made pilot experiment using ourselves and volunteers to track where they were focusing their attention and putting that data onto a heat map. From here we drew conclusions some for designing the prototype for the last iteration.

In the last iteration we had have a fully developed SGD prototype that made dynamic subtle guidance on the job applications. The idea is that when the participant starts to focus on the more non-objective parts of the job application the subtle cues will trigger. To examine the prototype, we're using a mixed method approach. First to get quantitative data from the eye tracker as in the first two iterations and afterward we get qualitative data asking the participant to fill out a questionnaire based on their experience when reviewing the job applications.

4.6 Experiment

In the last iteration for the SGD prototype, it was deployed in a controlled experiment to generate quantitative data. The participant will compare 20 job applications where 10 is with SGD and 10 without it. They will be informed that their eye movement will be tracked but information about the SGD will be masked until after data is collected to reduce bias. More information about the experiment will be presented in chapter 5.2.

4.6.1 CV design

The CV in our practical experiment was supplied to us from Sayaka Törngren who is the project leader of the project that this thesis is a part of [1]. Layout of the CV is a picture of the applicant, the name of the applicant, email, phone number, what type of job they are searching, education, experience, and further skills they have. The applicants ranged in ethical origin as some had common Swedish names and others had a more foreign

sounding name. The degree of education and experience were similar between the different CVs, our impression is that it was designed that way to make the biggest thing that varied were the picture and name of the applicants. The thesis work varied in the education section of the CVs.

5 Results

In this chapter, a detailed explanation of the experiment is presented as well as the result gathered from the participants during the experiments.

5.1 Controlled Experiment

The experiment in this thesis was created to evaluate how the stimuli will impact human gaze direction or more specifically, evaluate if the SGD prototype can guide a participant gaze to a specific AOI and influence their general experience when reading a CV. An example of the participant set up is shown in figure 5.1

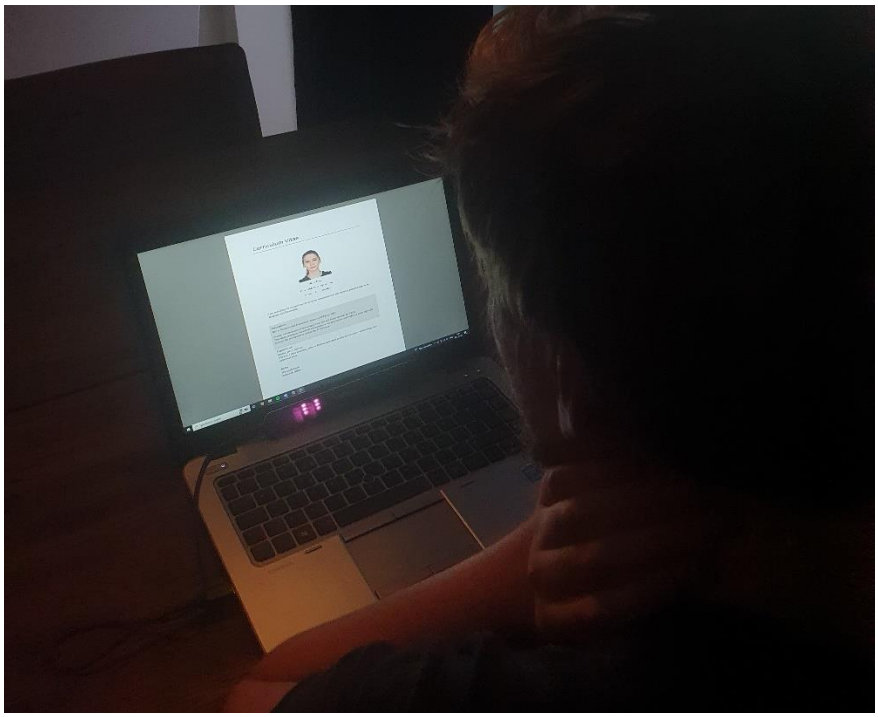

Figure 5.1 Example of participant set up with SGD active

5.1.1 Experiment task

The first thing the participant will do when the experiment starts is enter their name. This is only done for easy management of the output files described in section 5.2.4. Afterwards there was a calibration between the eye tracker and the participant. After the calibration the participant will be presented with the first CV as in figure 5.1. The CVs will be presented one at the time and the participant will choose when to move on to the next one and will grade the CV on a scale from 1-7. When they have read all, they are asked to pick three applicants which they would call back for an interview. A more detailed explanation on the experiment and information about the participants will be presented in the upcoming sections.


Curriculum Vitae

I am searching for an exciting career as an economist with the recently acquired degree in Business and Economics.

Education
BSc in Business and Economics, August 2018-June 2021

Thesis: Determinants of Sovereign Credit Default Swap spreads for PIIGS
This study examines the effects of changes in macroeconomic variables on sovereign CDS spreads for the countries within the PIIGS block.

Experience
Åhlens, 2017-Current
Work as a shop assistant, sales of fashion and other products, customer relationships and additional sales.

Skills
Microsoft Excel
Microsoft Office

Figure 5.2 Example of CV with subtle stimuli. Face and name are blurred for integrity

5.1.2 Participants

For the controlled experiment, there were 9 participants, 5 male and 4 female. Some were recruited from Högskolan Väst and others were volunteers. The participants were between 21 and 63 years old, had a Scandinavian ethnical background and had little to no knowledge about the experiment. Four of the participants had glasses but otherwise there were no major eye defects. Before the experiment, the participants signed a consent form which they kept (see appendix A).

Since the CVs were identical in design and had small changes in content, all participants were shown CVs in a randomized order. This reduces the learning effect and fatigue variations that otherwise would affect the result.

To make sure that all participants had the same experience when doing the experiment, they were sat under the same lighting and sound conditions. The lights were turned off and they were left alone in a room when reading and rating the CVs. This was done to reduce stress or inputs from the outside world.

5.1.3 Finite-State Machine

Two windows in Psychopy are used during the experiment. One for entering their name and one for the rest of the experiment. With that in mind, several different images or "scenes" need to be presented on the windows in a logical order depending on what part of

the experiment is being done. Therefore, a finite state machine was used and having the following states:

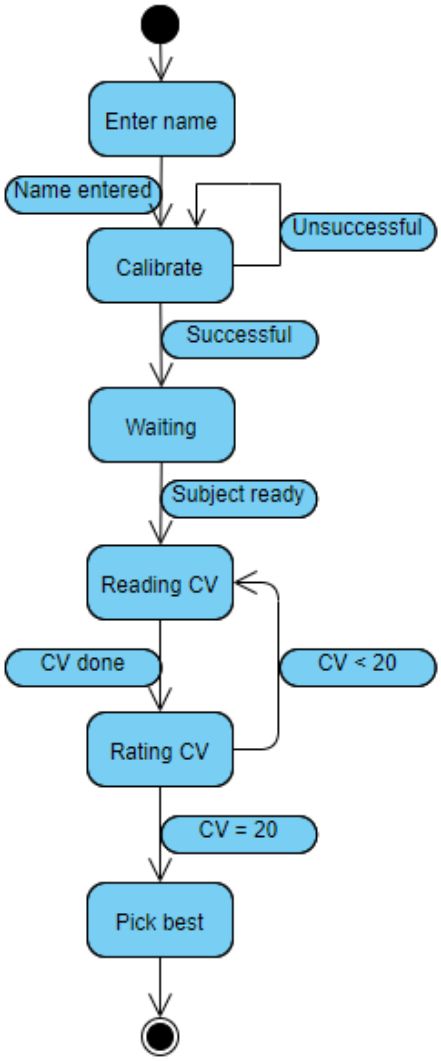

Figure 5.3 Finite state machine

Enter name. The participant is presented with a small window where they enter their name. After they enter their name, the window closes, and they move on to the calibration state.

Calibration. The gaze point is calibrated with every participant since not all eye characteristics are the same. The calibration is done using a sequence from the Titta toolbox made by Nyström [6]. First a blue circle is presented in the middle of the screen as a reference position on where the participant should position themself during the experiment. There is also a "head liked" circle indicating the current position of the participant. When the participant is correctly set up, they can start the calibration where they are introduced to a plus-shaped dot as a fixation point. The point moves around the screen to five different locations as an X-pattern. Afterwards a validation point is presented and moves to four different locations as a diamond shape. If the calibration is successful, they move on to the waiting state.

Waiting. Here the participant is presented with the validation image and can choose to move on with a tap on the spacebar on the keyboard.

Reading CV. During this state, the participants are presented with one CV at the time. The same conditions were exposed to all the participants where 10 the CVs had stimuli and the other 10 did not. Half of the participants were doing the experiment *with* stimuli on the first 10 CVs and *without* on the other 10 and vice versa on the other participants. When they are done reading one CV they move on to the next state with the right-arrow key on the keyboard.

Rating CV. When the participant enters this state, they are presented with a small window where they are asked to rate the current CV on a scale from 1 to 7 how likely they are to call that applicant back to an interview (see appendix A). If they have read less than all the CVs, they move back to the "Reading CV " state and are presented with a new CV. Otherwise they move on to the last state.

Pick best. In this state, the participants were asked to pick three applicants which they would call for an interview. Here they can move back and forth between all the applicants. After this, the experiment is finished, and relevant data is saved.

5.1.4 Recorded data

All data for each experiment is stored in two different TSV (Tab-Separated Values) files which can be used to evaluate the result. One file where all the eye tracking data is stored and one log file. A Python script file (recorded_data.py) is used for handling the data files and picking out the relevant data and variables and mapping them together.

Table 5.1 Description of log file

Variable	Description
ExperimentStarted	when the experiment started
Forward	when the participant moves to the next CV
Rating	the rating that was rated on a specific CV
Backwards	when the participant moves to the previous CV
StimuliStarted	when the stimuli start
Float value of stimuli	this variable indicates the opacity value when the participant looks away from the trigger zone
StimuliEnded	when the stimuli end
ReadAll	when the participant had read all the CVs ones
ExperimentEnded	when the experiment ends

All the variables in the log file have a timestamp attached to them and were used to compare to the timestamps in the eye tracker data file and the relevant data from each CV is used.

5.2 Data result

In this chapter, all the data gathered during the experiment will be presented. It will be divided into a quantitative section and a qualitative section.

5.2.1 Quantitative result

The quantitative results are only the sheer numbers that were gathered from the participants. The data that were gathered are:

- Rating on each CV per participant
- Time spent on each CV per participant
- The value on the stimuli opacity variable when stimuli ended

Since all participants were shown each CV in a randomized order, a table is used to illustrate in which order each CV was shown per participant. Every other participant had stimuli on the last 10 CVs (participant 1, participant 3, participant 5 etc.) and the others had on the 10 first CVs (participant 2, participant 4 etc.).

Table 5.2 the order of which the CVs were shown to the participants

Participant																				
1	CV:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	CV:	6	1	18	15	20	16	2	5	10	4	12	7	19	9	11	17	8	13	14	3
3	CV:	2	18	5	1	16	13	20	10	3	4	17	12	19	7	6	8	11	14	15	9
4	CV:	11	3	19	9	13	1	4	8	20	5	15	14	12	10	6	2	18	17	7	16
5	CV:	12	20	16	4	7	2	5	18	15	13	19	11	3	6	9	1	14	8	17	10
6	CV:	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
7	CV:	17	3	2	14	20	1	19	6	4	12	9	10	5	11	7	15	18	8	16	13
8	CV:	5	11	8	6	20	10	14	2	17	3	1	14	9	7	12	15	4	18	13	16
9	CV:	1	3	5	7	9	11	13	15	17	19	2	4	6	8	10	12	14	16	18	20

5.2.1.1 Result from participants

To make an analysis of how all CVs were rated, a diagram is used to take each rating per CV from all participants and add them together, as shown in figure 5.4

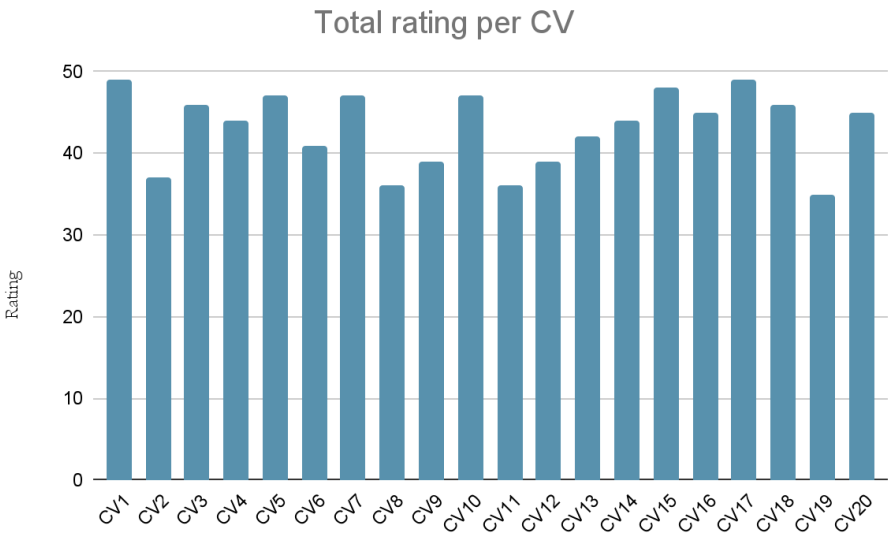

Figure 5.4 total rating per CV

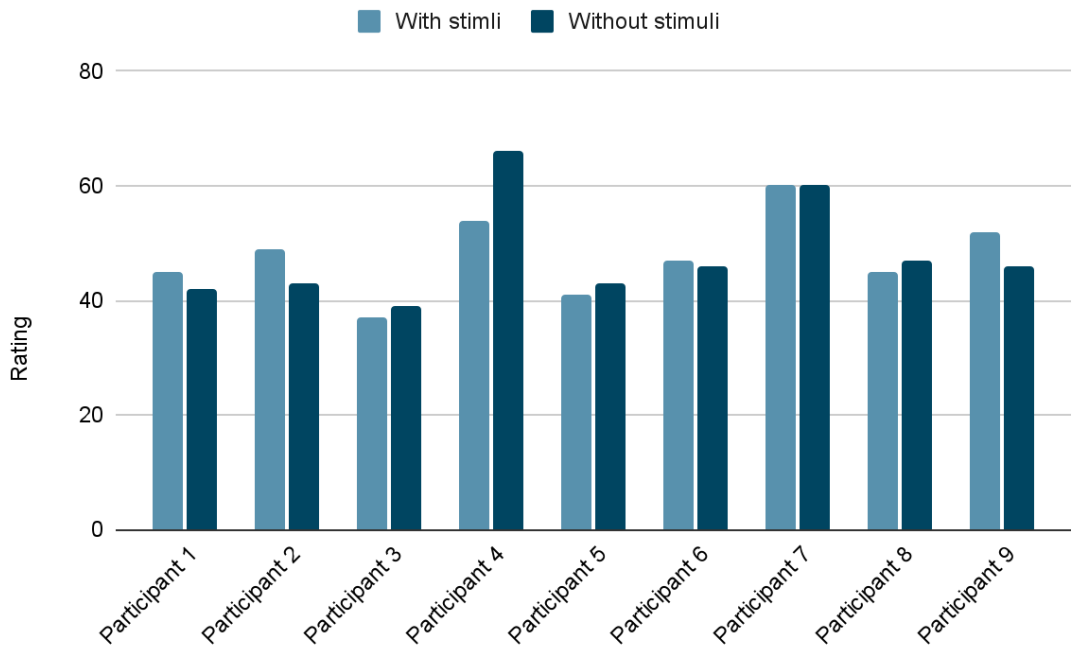

Figure 5.5 rating with and without stimuli showing how different the participants rated CV's

In figure 5.5, the chart is organized to show the difference in rating between having SGD or not. Here we can see that four participants gave better ratings with the SGD on than off. This result doesn't say that much, since the order that the CVs were read was

randomized and one participant could have most of the CVs with better rating when having SGD on and one participant when the SGD was off. After reading all the CVs, the participants were asked to pick 3 applicants that they would call in for an interview. The result from this is shown in figure 5.4, which presents the total amount that one applicant would get called in for an interview.

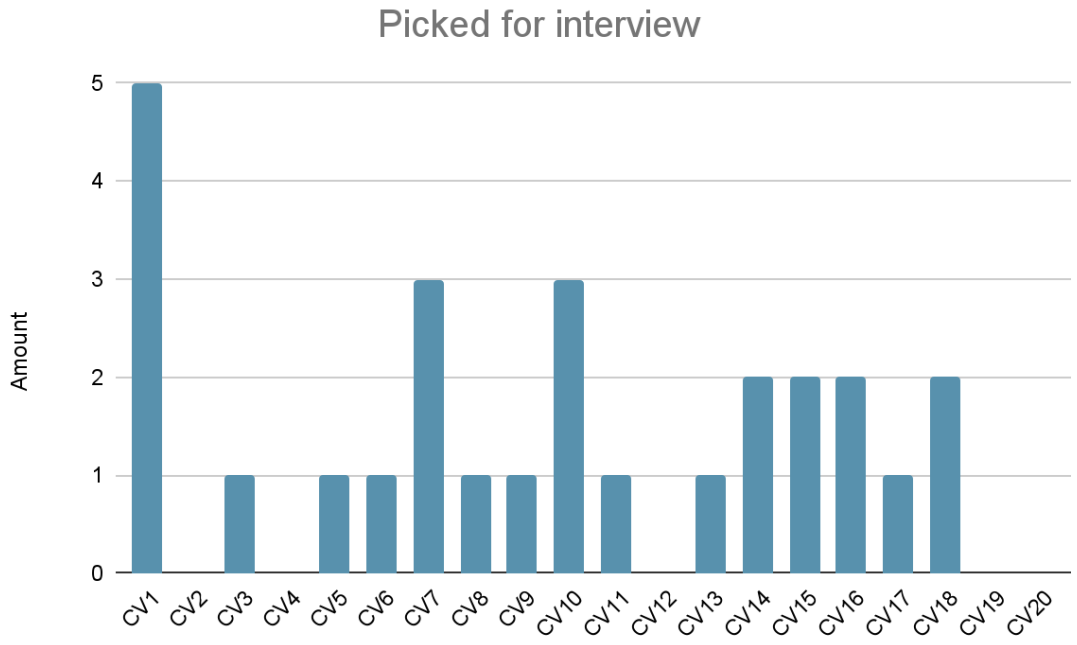

Figure 5.6 Total number of times one applicant were chosen for an interview

5.2.1.2 Result from data collected

From the recorded log file, the opacity value of when the stimuli have ended is used to get an understanding of when the participants were looking away from the trigger zone. All opacity values with a value of less than 0.01 are not used and are thrown away. The reason for this is that an opacity value of less than 0.01 is big enough to notice and should therefore be considered false positives. Figure 5.5 shows how many times each participant triggered the SGD.

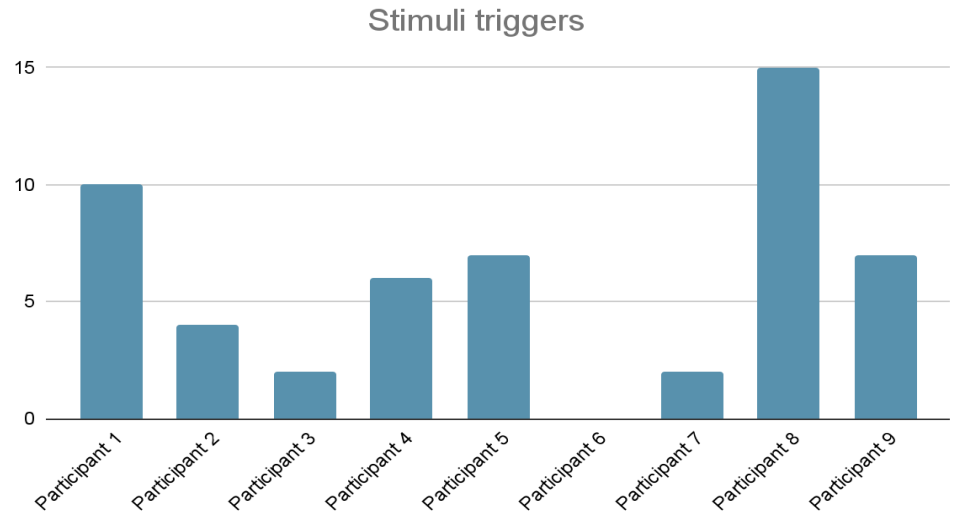

Figure 5.7 number of times each participant triggered the SGD

To see if the SGD had any effect on the participants, the timestamp of when the stimuli has ended is used as a start time for plotting a map of the upcoming gaze coordinates. A "heatmap" is used to check where the 20 next gaze coordinates are after the stimuli has ended; an example of this is shown in figure 5.6.

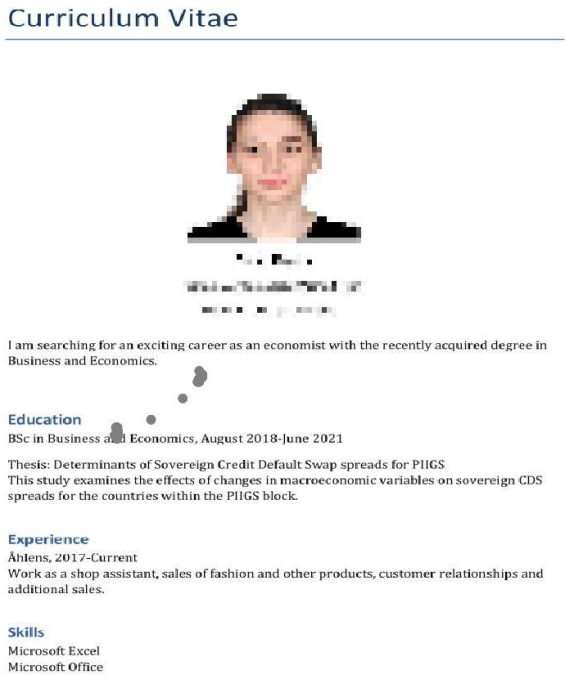

Figure 5.8 plotted gaze coordinates after the stimuli has ended

Out of the 53 times the SGD was triggered from all the participants, 17 of these times it was shown that the participant moved their gaze to where the SGD was shown. 17 times, the participants gaze was back at the trigger zone or there was no data to be gathered during the next 20 data samples. This could be due to the fact that the participant was

looking away or closing their eyes for a longer period of time. Out of the 53 times the SGD was triggered, 36 of these samples could be used for analysis in the discussion chapter.

To get an answer to research question 3, time is used to compare how fast the participants read the 10 CVs with SGD and the 10 without SGD. Figure 5.7 shows how much time the participants spent on the 10 first and the 10 last CVs and figure 5.8 shows the median time spent on 10 CVs with or without SGD.

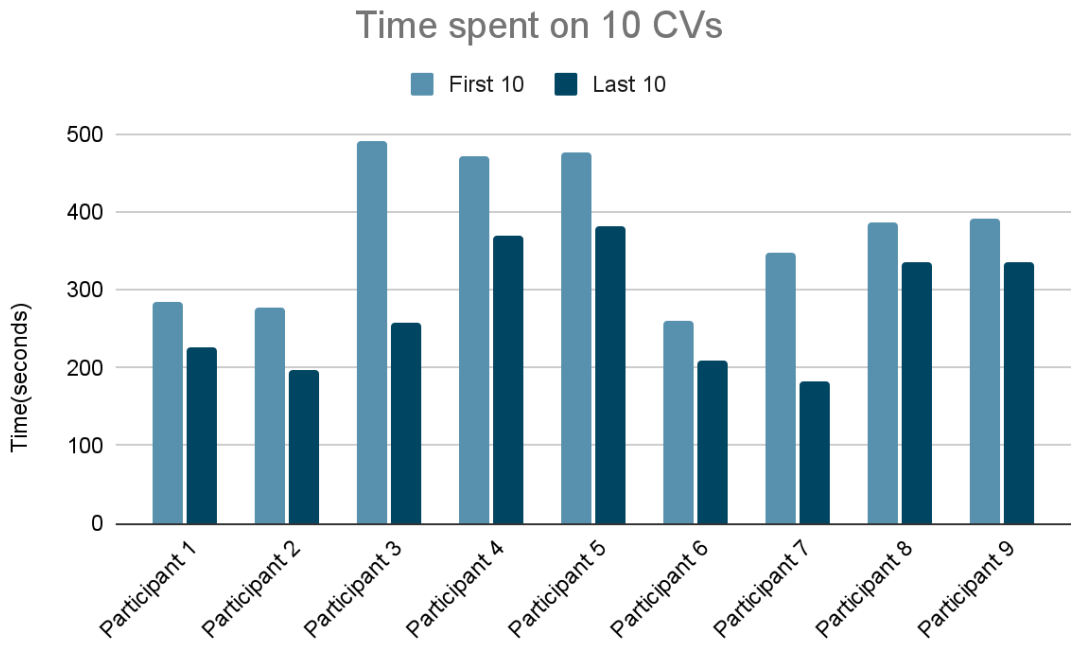

Figure 5.9 time spent on the first and last 10 CVs per participant

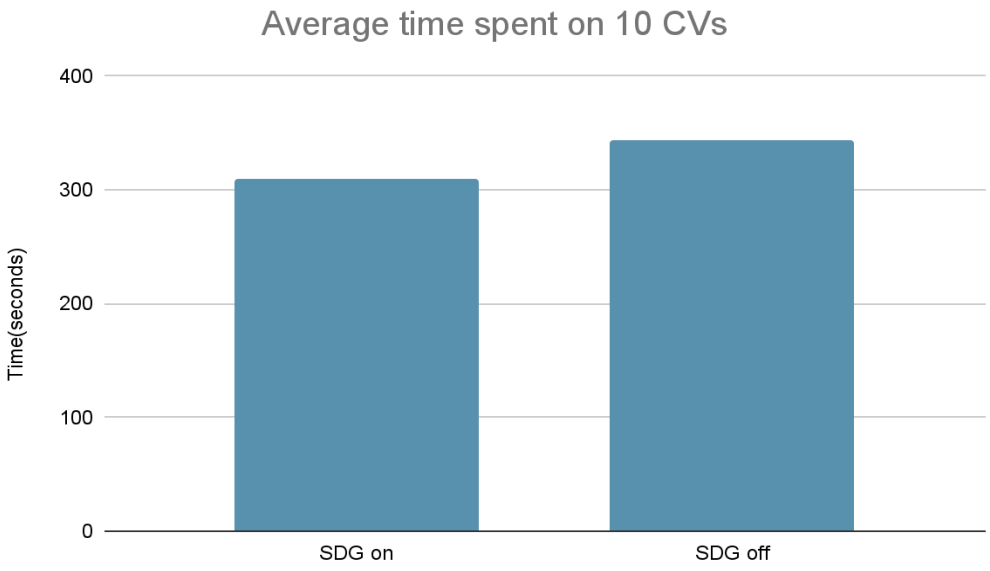

Figure 5.10 average time spent on 10 CVs with and without SGD for all participants

5.2.2 Qualitative result

After the experiment, the participant filled out a demographic questionnaire regarding gender and age. Out of the 9 participants 4 were female and 5 were male. 3 participants were in the 18-25 age group, 3 in the 26-35 age group, 1 in the 36-45 age group and 2 in the 46+ age group. This is shown in figure 5.11

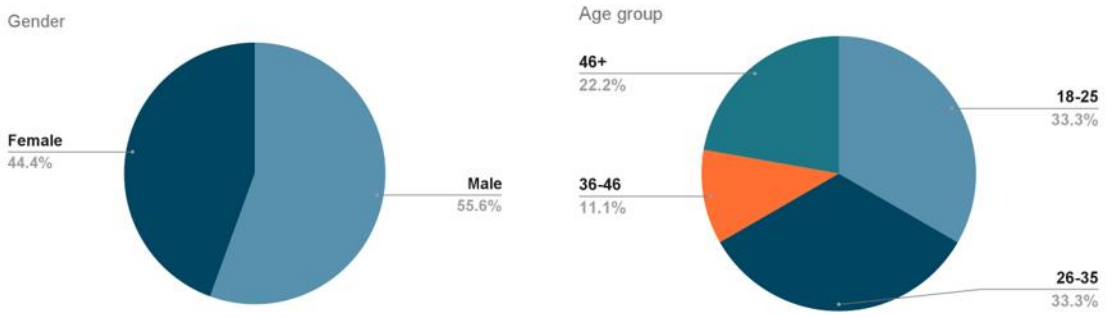

Figure 5.11 Age and gender of participants

Regarding the last two questions on the questionnaire, if the participants noticed the SGD or not, not a single participant said that they noticed anything unusual when reading the CVs regarding the SGD. 7 participants said that it was very unusual that the CVs were very similar in content and stated that they started to learn some paragraphs by heart, making them only need to read the first few words of a paragraph to know it's content on another CV.

Since none of the participants stated that they noticed the SGD, the last question on the questionnaire was completely irrelevant.

6 Discussion

In the field of Subtle gaze direction our thesis with using eye track in combination with stimuli to reduce discrimination on work applications is a previously unexplored area. This thesis presents an introduction of the area, our research question, related work that has been done in the area, method that we used and results of the practical experiments. Techniques we used is based on previous research, but the implementation and combination of all three areas eye tracking, stimuli to prevent racial discrimination on CVs have never been done before.

6.1 Result Analysis

Since this research area is very complex and it is hard to draw conclusions from the result that we got during the experiment, we decided to divide the result analysis into two parts. One which talks about the results that the participants entered and one which talks about the result gathered from the eye tracker.

6.1.1 Results from participants

When looking at the results from section 5.2.1.1, it is clear that some CVs were rated higher than others, indicating that those applicants are more likely to be called back for an interview. We can also see that there is a correlation between total rating per CV and number of times that an applicant was chosen to be one of the three that the participants chose to call back for an interview. The three CVs that were picked most times (CV1, CV7 and CV10) did also score high on total ratings.

The most interesting CV to look at is CV1. That applicant did score the highest on total rating and was chosen 66% more times than the second most chosen. That applicant was a female with a non-Swedish name or ethical background.

If we look at the applicants that scored the lowest on the total rating, we also see a correlation between total rating and being chosen for an interview, as the majority of the applicants that were never chosen for an interview also scored less than 40 on their total rating.

Looking at the six CVs that scored less than 40 on their rating, **all** of them had a Swedish ethical background and a Swedish sounding name.

The results here is really interesting since we expected the result to be the other way around on which applicant scored higher and which scored lower. When having informal discussions with the participants after the experiment, some of them stated that they were looking at the applicants' picture when choosing the three applicants to call for an interview, but they were looking at how "approachable" the applicant looked i.e., if they for example were smiling or looking generally happy on the picture. This is clear if we once again look at CV1 since that applicant had the biggest smiles out of all the applicants. And if we look at the CVs that scored less than 40 on their rating, all of them had a more

natural facial expression. With all this being said, we can adopt the idea that people have a bias when choosing applicants to call in for an interview, but the "approachableness" is a much bigger factor than the applicants ethnical background or name.

6.1.2 Results from gathered data

With the result from section 5.2.1.2, you can clearly see that the time spent reading the last 10 CVs is lower than the first 10 CVs. This is most probably due to the fact that all the CVs were similar in content and the participants learned some of the paragraphs by heart and that you are generally quicker after doing the same task over and over.

When looking at the average time spent reading 10 CVs, you can see a small difference in the amount of time spent with the SGD on. The difference is only 35 seconds, which is not a lot on 10 CVs. It's very hard to argue that this is due to our SGD prototype but rather different individuals learning curve. For example, participant 3 spent almost half the time on the last 10 CVs as the first 10, while only triggering the SGD twice.

If we look at how the gaze direction changes when the SGD is triggered, we can see that when the SGD has ended, the participant changed their gaze towards where the SGD was 47% of the time. A factor that we can't discard is that it's hard to know if the participants changed their gaze due to the SGD or other reasons for the remaining 53% of the time.

6.2 Methodology

In our experiments our goal was to answer this thesis research questions, which is: How do we counteract racial discrimination through eye tracking? How intense must the stimuli be to draw attention? How do people change their way in scanning job applications when exposed to subtle visual stimuli? The procedure that we used to answer the questions is using 20 CV which is similar to each other to reduce factors between the CV which isn't cause for discriminatory selection, when the participants did the experiment. The other reason for this layout on the CVs is it easier to collect valuable eye tracker data from the experiments to answer our thesis. In the experiments we collected both quantitative data and qualitative data from the participants to see how the data variated on the CVs with or without our SGD software running on the CVs.

To collect data, we used both quantitative and qualitative methods for our experiments. The quantitative data was collected in a log file that certain actions were written into the log file. Data that was written to the log file was the system's timestamp and messages of actions that was taken by the participant. Messages that were written to the log file were different configuration messages for the eye tracker, when the stimuli activates and how visible the stimuli have become before the user deactivates the stimuli. The stimuli are activated when the participant looks at the trigger zone which is the name and face on the CVs. Stimuli is deactivated when the participant is looking at the area which has stimuli on it.

The qualitative data that was collected was through the participant rating the different CVs from 1-7 where one is not likely to be called up for the job and 7 is likely to be called up for the job. After the participant has rated all the 20 CVs, they needed to select 3 of the CVs as the best candidates for the job.

The methods that were used for the practical experiments were supplied by Sayaka Törngren at Malmö university and by Marcus Nyström at Lund university as part of a major scientific research project. Material as the CVs was also supplied by Sayaka and Marcus for the practical experiments.

Some issues that have occurred when doing the practical experiment is that the CVs are similar in content and the participants after a while knew what information was in the CVs. Another issue that came to light is how to determine what behavior is racial discrimination on the eye tracker data the participants gave. The main issue is that there is no data base line of what racial discrimination on the eye pattern on CVs is. If this result represents the majority of the population is hard to say as we only had time for a small study and for more accurate results, we need a bigger case study.

6.3 Comparison with related work

The earlier work that has been done that is close to the thesis is work in *Subtle gaze direction* [9]. The author of the paper Bailey described how they used an eye tracker connected to subtle cues to change the participant's focus. The other article from Bailey [11] *Impact of Subtle Gaze Direction on Short-Term Spatial Information Recall* examined what type of impact subtle cues had on the participants who were exposed to stimuli. The article concluded that participants who were exposed to subtle cues have better short-term spatial information recall of the information which was focused on from the subtle cues.

Article on Tobii eye tracker [6] *Titta: A toolbox for creating PsychToolbox and Psychopy experiments with Tobii eye trackers* help us understand different functionalities for the eye tracker that was helpful in Titta toolbox. The article also gave us an understanding of how Psychopy works and how to use Psychopy with the combination of Titta toolbox.

Subtle gaze functionality described in [16] *Subtle Gaze Manipulation for Improved Mammography Training* where they described how they designed and implemented a certain time delay on the stimuli, then the participants focused its eye on a certain area before the stimuli would activate on the wanted area. They also implemented a timer that did not allow the user to change the picture before the average time it took for participants to read the picture was achieved. The effect of this functionality made it, so the participants made more meticulous look at the picture, which also generated better eye tracker data.

There is no prior work done in the particular field. What is meant by that is there are no prior research articles about using eye tracking with stimuli to counteract racial discriminations in work applications. There is research in each of the separate categories,

but not with all the areas combined that mean eye tracking, stimuli and counteracting racial discrimination.

6.4 SGD design

We designed the stimuli after the logic in article [16] where they let the participants use and look at pictures in X number of seconds before the stimuli was activated so that the participant had the ability to look at the right places before applying stimuli. The article [16] was about how to apply "Subtle Gaze Manipulation for Improved Mammography Training", in the article they discussed how they determined the amount of time the participant should have before the stimuli applied. In the article they also used two different techniques on using stimuli to guide the participant through a certain path through the picture, the second way was to only use stimuli to guide the participant to certain highlighted areas in the picture.

In the article they also discussed why it was necessary to make the participant wait a certain 10 seconds before being able to answer questions or change pictures.

They determined the time before the participant would be able to change pictures, through taking the average time it took to look at the paper and used the average time as the earliest time the participant could move on to the next picture.

We designed our stimuli with the consideration of the article and used the method of highlighting on area of interest through the use of stimuli. From the article we also decided to use the method of forcing the participant to wait X number of seconds before being able to change the CV. It makes it easier for us to gather data from the eye tracker and forces the participant to read the CV more thoroughly. For improving the SGD design, this will be covered in section 7.2.

6.5 Ethics

For our practical experiment on our SGD prototype, the participants have all filled in a consent form which approved us to save their tracked eye data and use their answers in the questionnaire in this thesis.

To protect the identity of the participants we will never use their name in the thesis. The name that they enter in the experiment is only used for easier management of the data files. The participants will only be represented as participant 1, participant 2 etc. in the thesis. There will also be no gathered photo of the participant, only the heat map of the eye tracker on the job applications.

7 Conclusion

In this chapter, we will try to draw a conclusion from our result and discussion and try to answer our research question and hypothesis stated in chapter 1. We will also talk about how this work can be further developed in section 7.2.

7.1 Research question and Hypothesis

Our three-research question were as followed:

1. How do we counteract racial discrimination through eye tracking?
2. Can we through subtle stimuli make people pay more attention to non-discriminative areas?
3. Can subtle stimuli speed up the assessment of a job application?

For the first research question, if we look at the result from section 5.2.1.1 it is almost impossible to say that we could counteract racial discrimination, since the result showed that there was no racial discrimination to begin with. Therefore, this question is impossible to answer.

Regarding research question 2, we can see in the results that we could change people's gaze focus with the use of subtle stimuli and pay more attention to the non-discriminative areas where the stimuli was active.

For the last research question, the result showed that there were minimal speed increases when assessing job applications with stimuli. With this in mind, it's very hard to answer if the speed increase was due to the stimuli.

With all the questions answered, our hypothesis that people are prone to be affected, and changed their eye movement patterns based on subtle cues was right. Although their judgment was not affected by this.

7.2 Future work

After analyzing our results, we realized that this subject needs further development in certain areas and some things could have been done differently. Some ideas for future work in this subject are:

More participants. When analyzing the result, we felt that it was hard to draw some correlation between the rating of the CVs and racial discrimination. If we were to do this study again, it would be interesting to have at least 30 participants, all from different walks of life, to give us more data to analyze.

Redesign stimuli. When we designed our SGD prototype, we used the same design model that's been used in previous research. The problem here is that the design model is

used for doing tasks or following instructions, i.e., the SGD is triggered when **NOT** looking at a particular AOI to guide them to look at it. Our SGD is triggered when the participant is looking at the name or face of the applicant to guide them to look away from that area. This was bad design since we realized that people don't look at an applicants face or name long enough for the SGD to be intense enough to catch their attention. What you should do is use a baseline for a non-discriminative eye movement pattern, and all eye movements that differentiate itself from that pattern should trigger the SGD.

More developed CVs. To make this research more applicable in a real-world environment, it would be a good idea to have more developed CVs, since some participants found it disturbing that they were so similar in content.

Isolate every parameter. Under the analysis of the results, and having informal discussions with the participants, we realized that there are more parameters to take in consideration than just ethnicity and name. It would be a good idea to isolate every parameter and make experiments on that.

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Appendix

A: Consent form

Consent form

About the study

You are going to be reviewing applicants for an entry level economist position that do not require any prior specialized skills. The CVs are standardized and have already gone through a pre-selection process. The candidates are all born and raised in Sweden. They have graduated in 2021 from a university in Sweden with a degree in Business and Economics and applying for work.

Your task

The task consists of review the candidates (only scroll forward). Please rate each of the 20 CVs how likely you are to invite that person for an interview (1=Will not call to an interview - 7=Will call to an interview).

During the task, we will record your eye movement and your rating of the different applicants.

After the task, you will be asked to fill out a short questionnaire where you will be asked to pick three applicants to call back and questions about your experience.

No data will be possible to associate with your name after the experiment and your identity will in no way be revealed in any publications or presentations.

All data from your eye movement may be used in publications and/or presentations but then only in anonymized format, together with data from other participants of the experiment.

If you have any questions or concerns about the experiment, the data collection process, your rights as a participant, or the confidentiality of your data, please feel free to discuss this with us.

If you change your mind at any point during the experiment and decide not to participate any further, please let us know and we will stop the experiment immediately.

The consent

By signing below, I confirm that I am at least 18 years old and have read the information about the study and the equipment being used. I understand the information and have had the opportunity to ask questions about the experiment.

I understand that I may ask for the experiment to be terminated at any time.

Yes □

Signature_____ Date_____

Name_____

I hereby grant permission for data stemming from

- my questionnaire responses
- recordings when performing the task to be made available to other researchers for further research, given that such secondary use of the data is governed by the confidentiality expressed in this form.

Yes □

Signature_____ Date_____

Name _____

Contact information:

Johan Mattsson

johan.mattsson.3@student.hv.se

Thomas Green

thomas.green@student.hv.se

B: Questionnaire

Demographics and after-experiment questionnaire

1. Which three people would you like to call back?
   a. _____
   b. _____
   c. _____
2. What is your gender?
   ☐ Female
   ☐ Male
   ☐ Prefer not to answer
   ☐ Other: _____
3. Age
   ☐ 18-25
   ☐ 26-35
   ☐ 36-45
   ☐ 46+
4. Did you see anything unusual while you were reading the CVs? (1 – yes certainly, 3 – maybe yes, 5 – no nothing)

   1 2 3 4 5
   ☐ ☐ ☐ ☐ ☐

   If yes, please describe: _____
5. Was the guidance provided on the screen disturbing in any way? (1 – yes, 3 – little bit, 5 – not at all)

   1 2 3 4 5
   ☐ ☐ ☐ ☐ ☐

   If yes, please describe: _____