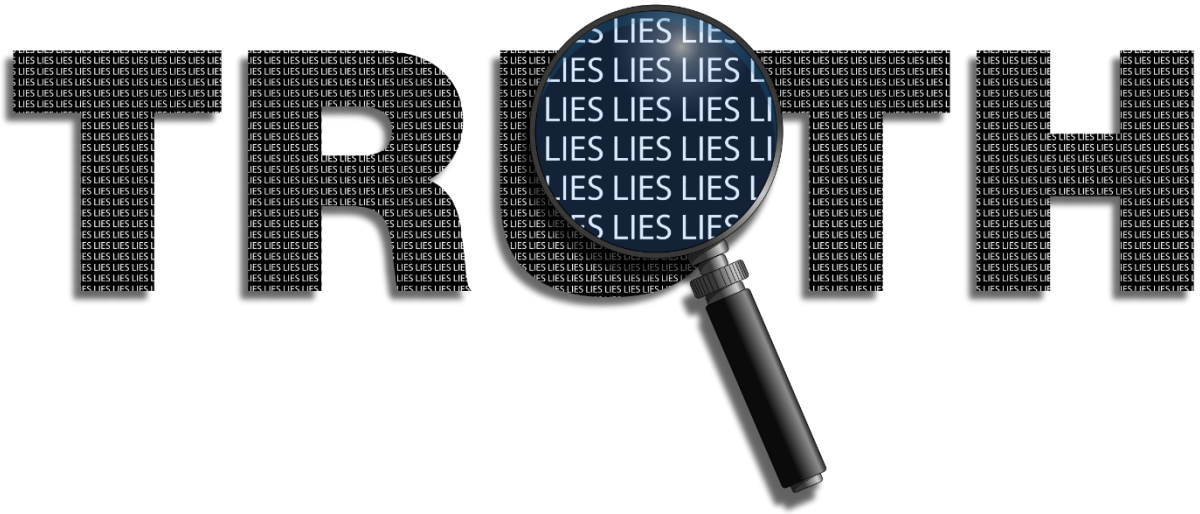
Cues to deception in the eyes

Examining eye contact and self-dissociation with eye tracking



Master thesis

Branda Wolters

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University of Twente

Psychology of Conflict, Risk and Safety

Faculty of Behavioral, Management and Social sciences

Supervisors:

Dr. ir. P. W. de Vries

Dr. M. Stel

Abstract

Detecting deception is an important factor in several professional contexts. However, people perform at chance level when detecting deception based on subjective indicators of deception and this becomes only slightly better when trained. Therefore, more objective technologies for detecting deception, such as polygraphs, have been developed. In the current study, there has been made use of eye tracking technology in combination with subjective cues to deception regarding the eyes as a new version of the polygraph in order to differentiate liars from truth tellers in interrogation settings. An experiment was conducted in which participants were asked to lie about witnessing a good friend committing an armed robbery. Based on participants' gaze behavior, it was examined whether liars made less eye contact with the interrogator than truth tellers and whether they dissociated themselves from the lie. Also, cognitive load was manipulated with a secondary task in order to check whether these effects became stronger. The findings provided insufficient evidence to support the hypotheses. So, in the current study, eye tracking technology could not differentiate liars from truth tellers in interrogation settings. Nevertheless, the current study provides a basis for future research on eye tracking technology in which recommendations have been made and more can be learned about differentiating liars from truth tellers with regard to cues to deception in the eyes.

Introduction

In general, detecting deception is an important factor in several contexts, for example in the forensic field. However, people perform at chance level when detecting deception based on subjective indicators of deception; a 54% average of correctly classifying truths and lies (Riggio & Friedman, 1983; Vrij, Granhag, Mann & Leal, 2011). Even when trained, people perform only 4% better (Frank & Feeley, 2003). Because people are not good in accurately detecting deception based on subjective cues to deception, more objective technologies have been developed in an attempt to achieve higher lie detection accuracy. Physiological response measurements such as polygraphs are frequently used. Furthermore, a new method has evolved using eye tracking technology (Kovalev, Luniakova, & Menshikova, 2016) which is the main focus in the current study.

Polygraphs are methods used to detect deception in a psychophysiological manner by measuring physiological responses as skin conductance, heart rate, voice frequency, breathing patterns, and facial expressions (Andreassi, 2000). The assumption is that lying and deceptive behaviors reflect in these physiological responses and that, therefore, responses of liars are different from those of truth tellers (Grubin & Madsen, 2007). Two main types of polygraphs are the Comparison Question Test (CQT) and the Concealed Information Test (CIT), both used in settings in which an interviewer poses questions to an interviewee. The CQT operates by asking questions which are relevant for the issue under investigation and comparison (control) questions which are nonspecific. The CIT operates using multiple choice questions with answers which contain one crime-relevant answer and non-crime-relevant control answers for the remainder. The assumption for both tests is that guilty subjects will react stronger to the relevant questions and answers than to the control questions and answers and innocent subjects will react the same to all question and answers (Bradley & Rettinger, 1992).

Nevertheless, for both polygraphs, the accuracy is debatable. In case of the CQT, the accuracy rate of correctly classifying guilty subjects is moderately high (87-98%). However, the accuracy rate of correctly classifying innocent subjects is rather low (55-56%), which means a quite high rate of falsely classifying innocent subjects as guilty (Patrick & Iacono, 1989; Patrick & Iacono, 1991). For the CIT, it is the other way around. Here, the rate of innocent subjects being correctly classified is quite high (94-98%) and the rate of guilty subjects being correctly classified relatively low (42-76%) (Elaad, 1990; Elaad, Glinton & Jungman, 1992). Therefore, the accuracy of these polygraphs is debatable.

Another, quite new, objective technology in distinguishing liars from truth tellers with similar intentions as the polygraph is eye tracking. An eye tracking device measures a person's exact point of gaze or eye movement when performing a task. It provides information about people's gaze behavior. Eye trackers are mostly using video-based methods which enable measuring eye movements to be non-invasive (Borys, Plechawska-Wójcik, 2017). Eye tracking has been applied interdisciplinary such as in fields of psychology, marketing, industrial engineering, and computer science (Duchowski, 2017). The most commonly measured concepts in eye tracking that can give insight into people's gaze behavior are eye fixations and saccades. An eye fixation is formed when multiple gaze points on a certain object, which are close to each other regarding time and space, form a cluster. A fixation describes a period of time in which the eyes are locked towards a specific object. In between fixations, the eyes make saccades which are quick movements of the eyes in which the eyes jump from one object to another (iMotions, 2017). Gaze behavior is formed by fixations as well as saccades and can demonstrate to which stimuli the attention of the eyes is drawn to. It can give an indication of what the attention of a person is focused on (Frischen, Bayliss & Tipper, 2007).

Applied to detection of deception, eye tracking has similar intentions as polygraphs. The same setting can be applied as well in which an interviewer poses questions to an interviewee. However, now, the focus is on people's gaze behavior instead of on their physiological responses. For example, people could be interrogated or could be shown incriminating footage wearing eye tracking glasses in order to check where one is fixated on or gazing at. Previous studies, which focused on detecting concealed information using eye tracking technology, already found that it is possible to distinguish liars from truth tellers based on people's gaze behavior (Derrick, Moffitt, & Nunamaker, 2011; Schwedes & Wentura, 2011). Furthermore, there are cues to deception that can differentiate liars from truth tellers based on their gaze behavior (Sporer & Schwandt, 2007; DePaulo, Lindsay, Malone, Muhlenbruck, Charlton & Cooper, 2003; Vrij, Mann, Leal, & Fisher, 2010). The combination of eye tracking with these cues to deception might form a new, and perhaps improved, version of the polygraph. In this study, it is going to be examined whether it is possible to detect liars in interrogation settings using eye tracking in combination with cues to deception concerning gaze behavior. The following research question is formed: *To what extent can eye tracking technology be used in differentiating liars from truth tellers in interrogation settings?*

Theoretical Framework

An often used definition of deception according to DePaulo (1988) is: "(…) an act of purposefully conveying to others information the deceiver believes to be false. Deceivers are (…) deliberately misleading others; they are not doing so mindlessly or mistakenly" (p. 155). When misleading others, deceivers do not want to be caught. Therefore, they try to hide and control verbal and nonverbal cues that might lead to the detection of their lies (DePaulo, 1988).

There are three main approaches in predicting people's behavior when they are lying. These approaches are the emotional approach, the attempted control approach, and the cognitive load approach. According to the emotional approach, lying causes physiological reactions due to increased arousal. The approach emphasizes that lying comes with stress caused by feelings of guilt or fear. Liars experience guilt because they are aware that they act against common values, and fear of being caught (Zuckerman, DePaulo & Rosenthal, 1981; Riggio & Friedman, 1983). Therefore, liars leak experienced emotions due to increased tension and nervousness. Actual indicators of detecting these experienced emotions are through verbal behaviors as a higher pitch of voice and speech disturbances (Zuckerman, DePaulo & Rosenthal, 1981; Ekman, 1992).

In addition to verbal behaviors, there are also nonverbal behaviors through which liars may leak cues to deception. The attempted control approach argues that liars attempt to hide any leakage of cues to deception through nonverbal behaviors by controlling these nonverbal behaviors. In general, (lay) people assume that liars show an increase in the frequency or intensity of nonverbal behaviors such as body movements. Therefore, liars try to show the opposite behavior – fewer body movements – in order to hide a lie and to appear credible (Sporer & Schwandt, 2007; DePaulo et al., 2003). However, this leads to showing unusual inhibition in body movements which then actually gives away that they are lying (DePaulo, Kirkendol, Tang, O'Brien, 1988, Vrij & Semin, 1996). Also, when controlling their nonverbal behaviors, liars will appear less involved, less spontaneous, less convincing, and more tense (DePaulo et al., 2003; Sporer & Schwandt, 2007).

Further, according to the cognitive load approach it is cognitively more demanding to lie than to tell the truth (Vrij, Fisher, Mann, & Leal, 2006; Vrij et al., 2010; Vrij et al., 2011; Vrij & Granhag, 2012). With lying, it is cognitively demanding to formulate and remember a lie as well as to maintain the lie consistently. Further, it is cognitively demanding for liars to

monitor and control their behaviors in order to appear honest and to monitor the reaction of the person that has been lied to in order to assess credibility of the lie. In addition, activating a lie is more cognitively demanding than activating the truth as activating the truth usually happens automatically. Moreover, suppressing the truth requires cognitive demands (Vrij et al., 2011). Due to this cognitive load, liars might show verbal cues to deception as longer pauses between question and answer, within statements, slower speech rates, and more speech disturbances (Vrij & Semin, 1996; Zuckerman, DePaulo & Rosenthal, 1981). Furthermore, the cognitive demands when lying cause nonverbal cues as fewer body movements (Ekman, 1992) and a reduction in eye contact with the person to be deceived (Sporer & Schwandt, 2007; Zuckerman, DePaulo & Rosenthal, 1981).

Applied to eye tracking, cues to deception regarding liars' eyes can be examined rather precisely with eye tracking technology. Therefore, reducing eye contact with the person to be deceived as a cue to deception will be elaborated on. Less eye contact with the person lied to is caused by cognitive load as well as by feelings of guilt and fear (Sporer & Schwandt, 2007; Zuckerman, DePaulo & Rosenthal, 1981). In research of Vrij et al. (2010), it was found that requesting mock suspects to maintain eye contact with the interviewer during a staged interrogation increased the presence of other nonverbal cues to deception due to increased cognitive load. Therefore, liars look away in order to manage their cognitive load. Furthermore, liars show less eye contact when a lie involves feelings compared to when there has been lied about facts only (Sporer & Schwandt, 2007). Also, in the meta-analysis of DePaulo et al. (2003), it was shown that liars who were motivated to make the lie succeed made less eye contact than liars who were less motivated and truth tellers because the necessity to make a lie succeed already increases cognitive load. However, in general, the relationship between eye contact and deception is found to be quite weak or even non-existent (Sporer & Schwandt, 2007; DePaulo et al., 2003). Although this relationship has been

examined multiple times, it has not yet been examined using eye tracking techniques which would give a much more precise location of where the eyes of the liar are fixated on in the face of the person lied to. Therefore, in the current study, the relationship between eye contact and deception will again be examined using eye tracking technologies:

H1. Liars will show less eye contact with their collocutor than truth tellers.

Next to verbal and nonverbal behaviors, the words liars are using for their deceptive stories can also be an indicator for deception. Liars have a certain control over the choice of words. However, as liars are also human, a lie may become transparent through the way the words are used. First of all, liars may have feelings of guilt and discomfort which could lead to using more negative emotion words in telling their lies. Second, liars tell less complex stories due to cognitive load. It is less cognitively demanding to compile a story with simple, concrete actions and leave out all the additional (also false) information (Newman, Pennebaker, Berry & Richards, 2003). Third, liars tend to use fewer first-person pronouns. They do so because they have a lack of personal experience in their story (Knapp, Hart & Dennis, 1974) or because they want to dissociate themselves from the lie in order to avoid self-incrimination and responsibility for the lie (Taylor, Larner, Conchie & Menacere, 2017).

So actually, by using fewer first-person pronouns, liars will get the feeling that they are less confronted with their own lies. Another reason why liars are less confronted with their own lies is because they usually do not receive accurate feedback on their lying behavior (e.g. in face and body) because they do not see themselves (Ekman, 1992). When placing a mirror, liars have the possibility to look at their self-image. Consequently, they will be confronted with their own lying behavior because, now, they do receive feedback and will, therefore, become more self-aware (Lawson, Stedmon, Zhang, Eubanks & Frumkin, 2013). Looking in

the mirror might increase tension and therefore impede deceiving (DePaulo et al., 2003). That is why it is expected that liars will avoid looking at their self-image when deceiving. This is also something that can be examined rather precisely with eye tracking technologies:

H2. Liars will glance less at their self-image compared to truth tellers.

Increasing cognitive load

One way to find out whether or not someone is lying is by manipulating cognitive load. As described above, lying is cognitively demanding. It increases activation of executive areas in the brain such as in the prefrontal cortex. The prefrontal cortex is important for adaptive behaviors in difficult situations. Liars need to remember the lie, need to keep their stories straight, need to withhold the truth, and have to monitor themselves and the person lied to all at the same time. As a result of executing multiple cognitive tasks simultaneously, liars will show reductions in other behaviors which are, at that moment, perceived by the brain as less necessary (Spence, Hunter, Farrow, Green, Leung, Hughes, & Ganesan, 2004). Examples are cues to deception as fewer body movements, longer pauses between answers and questions, slower speech rates, and more speech disturbances (Ekman, 1992; Vrij & Semin, 1996; Zuckerman, DePaulo & Rosenthal, 1981). Also, less eye contact with the person lied to (H1) and less looking at one's self-image (H2) when that is possible (e.g. when there is a mirror present) are behaviors that might occur when lying is cognitively demanding due to an increased activation of the executive areas in the prefrontal cortex.

A way to enhance the detection of lies is by increasing cognitive load to make it even more demanding for liars to maintain their lie consistent. This can be achieved by making additional requests. In interrogation settings, interviewees could be asked to tell their story in reverse chronological order. Also, interviewers could pose unanticipated questions to the

interviewees (Vrij & Granhag, 2012). Another way to deplete liars' cognitive resources is to require them to execute a secondary task during the interrogation (Vrij et al., 2006). For example, interviewees could be instructed to avoid mentioning a certain commonly used word out loud. The expectation is that liars will behave differently in reaction to the secondary task compared to truth tellers and that, therefore, behavioral differences between liars and truth tellers become even more clear. Subsequently, there can be discriminated more adequately between liars and truth tellers (Vrij & Granhag, 2012).

So, the aim with increasing the cognitive load is to intensify liars' already shown behaviors. Telling the truth is cognitively little demanding because a story is based upon real, not made up, experiences. It is expected that truth tellers, therefore, will show the same behaviors (e.g. regular eye contact with the interviewer) when cognitive load is increased as when it is not. Lying, on the other hand, depletes cognitive resources. Hence, as described previously, people will show inhibitions in certain behaviors when lying (e.g. less eye contact with the interviewer). So, when cognitive load is increased, lying will be even more cognitively demanding. Then, inhibitions in these behaviors will be reduced even more. For example, liars will then make even less eye contact with the interviewer. In the current study, increasing cognitive load can be added to the first and second hypothesis. It will be expected that increasing cognitive load will cause liars to make even less eye contact with their collocutor and glance even less at their self-image compared to truth tellers:

H3. The difference in gaze behavior, eye contact with the collocutor, between liars and truth tellers will be enlarged when increasing cognitive load.

H4. The difference in gaze behavior, glancing at their self-image, between liars and truth tellers will be enlarged when increasing cognitive load

Method

Participants & design

A total of 129 participants took part in the experiment. Three participants were excluded from the sample size due to badly trackable pupil movement, hence, 126 participants remained. The participants were recruited using the researcher's social circle and the test subjects pool SONA of the University of Twente. The experiment was conducted in either a clubhouse in Wijtgaard, Friesland (45.2%) or in a research room at the University of Twente in Enschede, Overijssel (54.8%). The sample size consisted of 35.7% males and 64.3% females with a mean age of 31.6 (*SD* = 15.3; range 16 – 74 years). Further, 81% was Dutch and 19% was German with various educational backgrounds (secondary education: 8.7%; vocational education (MBO): 13.5%; higher education (HBO): 36.5%; university education (WO): 41.3%). All participants had normal or corrected-to-normal vision. The study had a 2 (Lying: yes vs. no) x 2 (Cognitive Load: high vs. low) x 2 (Stage: baseline vs. experiment) mixed-participant factorial design with Lying and Cognitive Load as between-participant variables and Stage as within-participant variable. The dependent variables were total fixation duration and fixation count on the eyes of the interrogator and on participants' self-image.

Procedure

The experiment took place in individual sessions of approximately 15 minutes. Before the experiment, participants received an informed consent which they needed to sign in order to participate to the experiment (appendix A). Then, the Tobii eye tracker glasses (see figure 1) were placed over the participants' eyes and subsequently calibrated. The Tobii eye tracker glasses were connected to a tablet which recorded the gaze behavior of the participants throughout each session. Next, the participants were instructed to take place in front of a laptop with a front camera on which the entire experiment took place. For each session, the

participants needed to read instructions on the laptop, followed by watching a video, followed by a short questioning about the video via Skype, an online video chat platform, with an interrogator (a fellow student of the researcher) asking the same questions to each participant. The reason for Skype was because then the cues to deception – making eye contact and glancing at the self-image – from the hypotheses could be examined at once in one setting (see figure 2). In order to minimalize external variables of cognitive load, the interrogation questions were asked in either Dutch or German, depending on the nationality of each participant. In total, two different interrogators contributed to the research; one in Friesland, who only spoke Dutch, and one in Overijssel, who spoke both Dutch and German.

Figure 1. Tobii eye tracking glasses

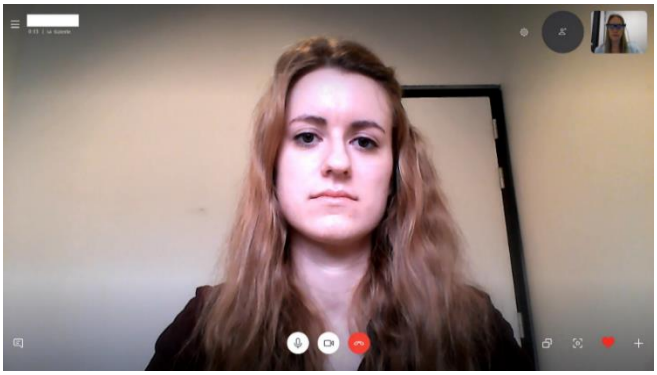

Figure 2. Skype interface

Stage

First, the baseline Stage took place. A baseline was created in order to filter out personal differences between participants. First, the participants had to read instructions (see appendix B.2). Then, a video of approximately two minutes of wild animals in nature was shown to the participants (see figure 3). Subsequently, a short interrogation about the video took place via Skype with the interrogator who was in front of a computer screen in another room. All participants were asked the same questions about the shown video (e.g. *Which animals did you see?*). See appendix G for all the questions. After the questions were posed and answered, the Skype session was shut down.

Next, the experimental Stage took place. The participants again had to read instructions followed by a video of approximately two minutes about a person committing an armed robbery in a gas station (see figure 4). The participants were told that the police wanted to question everybody that was near the crime scene and that the concerning participant was up next. This interrogation was again a short questioning via Skype in either Dutch or German administered by the same interrogator. All participants were asked the same questions about the crime (see appendix H). First, a couple of general questions (e.g. *What do you think of the crime you just witnessed?*) followed by a couple of crime specific questions (e.g. *How many persons were committing the crime?*). The participants were told that the interrogator did not see the video just as in a real investigation in order to stimulate the participants to participate seriously. After all the questions were posed and answered, the Skype session was shut down.

Figure 3. Screenshot baseline video

Figure 4. Screenshot experimental video

Lying and Cognitive Load

The baseline Stage was for all participants the same. However, in the experimental Stage, the participants were randomly instructed to either lie (i.e. Lying: yes) or tell the truth (i.e. Lying: no). Participants in the lying condition were instructed to perceive the person in the video who committed the crime as a close friend who needed to be protected. Therefore, the participants were instructed to deceive the interrogator by answering as few questions as

possible with the truth and to do this in a way in which the interrogator would not notice. It was also emphasized that the interrogator was a police officer in order to motivate the participants to appear credible. In order to motivate the participants in this condition even further to participate seriously, it was mentioned that the participant who appeared most credible would win a smartwatch. See appendix C for the instruction form.

Participants in the truth telling condition were instructed to answer every question with the truth. If a participant would not know an answer to a question, they were instructed to mention that they did not know the answer instead of making up an answer. See appendix E for the instruction form. Further, a manipulation was added (i.e. Cognitive Load: high vs. low). In both conditions (i.e. Lying: yes and Lying: no), half of the participants were randomly assigned a secondary task to increase cognitive load. They were instructed to avoid mentioning filler words as "um" or "uh". See appendixes D and F for the instruction forms.

Post-experiment questionnaire

Lastly, after finishing the experimental Stage, participants had to fill out a questionnaire which measured three variables (see appendix I for all the items). First, the perceived cognitive state of the participants was measured consisting of eight statements (e.g. *During the interrogation I tried to hide my nerves.*) with a 5-point Likert scale (*strongly disagree – strongly agree*). De Cronbach's alpha for perceived cognitive state was α = .66 which indicates a reasonable reliability for this scale. Second, the perceived cognitive load of the participants was measured consisting of five statements (e.g. *I experienced the experiment as cognitively demanding.*) with a 5-point Likert scale (*strongly disagree – strongly agree*). This variable was derived from de NASA-TLX (Task Load Index), a multidimensional assessment tool aimed at rating subjective experiences of workload to assess various aspects of performance (Hart & Staveland, 1988). De Cronbach's alpha for perceived cognitive load

was α = .72 which indicates a reasonable to good reliability for this scale. Third, it was measured how participants perceived their own gaze behavior towards the eyes of the interrogator and their self-image. Perceived gaze behavior was measured by means of two statements (i.e. *I tried to avoid looking into the eyes of the interrogator/at the frame of my self-image in Skype*) with a 5-point Likert scale (*strongly disagree – strongly agree*). There was a strong, positive, statistically significant correlation between the both statements of perceived gaze behavior, $r_s(124) = .230$, $p = .009$.

After the questionnaire, a short debriefing was held in which the researcher explained the real purpose of the research, thanked the participants for their participation and asked if they still had questions about or negative feelings towards the experiment. Further, the researcher indicated that the participants could contact the researcher for any further questions. Also, it was emphasized that the participants could not discuss the experiment with other participants.

Tobii Pro Lab

In order to detect whether participants were having eye contact with the interrogator and were glancing at their self-image during the experiment, areas of interest (AOI) were created in the Skype interface (see figure 5) with Tobii Pro Lab (64x), the software that belongs to the Tobii eye tracking glasses. AOIs were created on the eyes of the interrogator in the center of the screen (AOI 1) and on the little frame of participants' self-image in the upper right corner (AOI 2). In order to gather accurate results in Tobii Pro Lab, the AOIs needed to be static frames. However, in contrast to AOI 2, AOI 1 was a dynamic frame. So, in order to make AOI 1 a static frame, the interrogator was placed on a static chair and was instructed to sit still in a static position during each interrogation. In this way, Tobii Pro Lab could recognize the eyes of the interrogator as a static frame during the analysis of the recordings.

By means of automatic mapping, Tobii Pro Lab mapped the participants' eye fixations from the recordings onto snapshots that were made from the point of view of the participants (see figure 5). Tobii Pro Lab needed to map an average duration of 82.18 seconds for the baseline Stage and an average duration of 115.69 seconds for the experimental Stage. On each day of conducting the experiment, a new snapshot was made to correct for differences in the interrogator's clothing and hairstyle. In this way, it was made sure that Tobii Pro Lab could compare the snapshots with the recordings. Each automatically mapped fixation was also checked manually by the researcher. When an automatically mapped fixation was wrongly placed, the fixation was manually corrected by the researcher. After mapping all the recordings, Tobii Pro Lab converted the data of the metrics – total fixation duration and fixation count – into an Excel file, which subsequently was being implemented into IMB SPSS Statistics 25 in order to conduct data analyses.

Figure 5. AOI 1 (red) and AOI 2 (green)

Dependent variables

The dependent variables of the experiment were total fixation duration (in seconds) and fixation count on the eyes of the interrogator and on the participants' self-image in Skype. The eyes of the interrogator (AOI 1) were important for hypothesis 1 and 3 and the little frame of participants' self-image (AOI 2) was important for hypothesis 2 and 4 (see figure 5).

The post-experiment questionnaire included three dependent variables. First, perceived cognitive state, in which participants rated their experienced tension and nervousness. Second, perceived cognitive load, in which participants rated their experienced mental effort. Third, perceived gaze behavior, in which participants rated their own gaze behavior towards the eyes of the interrogator and towards their own self-image to get an idea about how the participants perceived AOI 1 and AOI 2.

Results

Several analyses have been performed. First, the main areas of interest of the hypotheses, the eyes of the interrogator and participants' self-image, were examined. Then, the variables of the post-experiment questionnaire were examined. Last, explorative areas of interest in the Skype interface, besides the interrogator's eyes and participants' self-image, were looked into.

Main areas of interest

It was examined whether lying and increasing cognitive load had effects on participants' gaze behavior towards the eyes of the interrogator and towards their self-image. All hypotheses were analyzed by means of 2 (Lying: yes vs. no) x 2 (Cognitive Load: high vs. low) x 2 (Stage: baseline vs. experiment) repeated measures MANOVA tests. The results are displayed in table 1.

Total fixation duration

A repeated measures MANOVA test analyzed total fixation duration (in seconds) on both AOI 1 and AOI 2 for Lying and Cognitive Load over both Stages. The results showed that there was no statistically significant main effect for Lying on AOI 1 and AOI 2, $F(2, 121)$

= 0.28, p = .76; Wilks' λ = 1.00, and for Cognitive Load on AOI 1 and AOI 2, $F(2, 121)$ = 0.27, p = .76; Wilks' λ = 1.00. However, there was a statistically significant main effect for Stage on AOI 1 and AOI 2 as a group, $F(2, 121) = 46.72$, $p < .01$; Wilks' λ = 0.56. Univariate analyses revealed that participants' total fixation duration on AOI 1 was significantly longer in the experimental Stage (M = 30.08, SD = 23.88) than in the baseline Stage (M = 16.50, SD = 13.41), $F(1, 122) = 92.29$, $p < .01$. Yet, Stage has no statistically significant effect on AOI 2, $F(1, 122) = 0.62$, p = .43.

Further, there was no statistically significant interaction effect between Lying and Stage on AOI 1 and AOI 2, $F(2, 121) = 1.44$, p = .24; Wilks' λ = 0.98, between Cognitive Load and Stage on AOI 1 and AOI 2, $F(2, 121) = 0.03$, p = .98; Wilks' λ = 1.00, between Lying and Cognitive load on AOI 1 and AOI 2, $F(2, 121) = 0.07$, p = .93; Wilks' λ = 1.00, and between Lying, Cognitive Load, and Stage on AOI 1 and AOI 2, $F(2, 121) = 0.24$, p = .79; Wilks' λ = 1.00.

Fixation count

A repeated measures MANOVA test analyzed fixation count on both AOI 1 and AOI 2 for Lying and Cognitive Load over both Stages. The results showed that there was no statistically significant main effect for Lying on AOI 1 and AOI 2, $F(2, 121) = 0.24$, p = .79; Wilks' λ = 1.00, and for Cognitive Load on AOI 1 and AOI 2, $F(2, 121) = 0.30$, p = .74; Wilks' λ = 1.00. However, again for Stage, a statistically significant main effect was found on AOI 1 and AOI 2 as a group, $F(2, 121) = 44.56$, $p < .01$; Wilks' λ = 0.58. Univariate analyses revealed that participants' fixation count on AOI 1 was significantly higher in the experimental Stage (M = 79.14, SD = 64.05) than in the baseline Stage (M = 47.66, SD = 38.06), $F(1, 122) = 88.21$, $p < .01$. Yet, Stage has no statistically significant effect on AOI 2, $F(1, 122) = 0.49$, p = .49.

Further, a close to statistically significant interaction effect was found between Lying and Stage on AOI 1 and AOI 2 as a group, $F(2, 121) = 1.76$, $p = .18$; Wilks' $\lambda = 0.97$. Pairwise comparisons revealed that liars' ($p < .01$) as well as truth tellers' ($p < .01$) fixation count on AOI 1 was significantly higher in the experimental Stage (liars: $M = 82.62$, $SD = 8.10$; truth tellers: $M = 75.26$, $SD = 8.21$) than in the baseline Stage (liars: $M = 48.94$, $SD = 4.81$; truth tellers: $M = 46.05$, $SD = 4.88$). For AOI 2, there was no statistically significant difference between the baseline and experimental Stage for liars ($p < .53$). For truth tellers, fixation count was higher (yet not significant, $p < .11$) in the experimental Stage ($M = 4.32$, $SD = 1.09$) than in the baseline Stage ($M = 3.02$, $SD = 0.54$). Further, no statistically significant interaction effect was found between Cognitive Load and Stage on AOI 1 and AOI 2, $F(2, 121) = 0.09$, $p = .92$; Wilks' $\lambda = 1.00$, between Lying and Cognitive load on AOI 1 and AOI 2, $F(2, 121) = 0.09$, $p = .92$; Wilks' $\lambda = 1.00$, and between Lying, Cognitive Load, and Stage on AOI 1 and AOI 2, $F(2, 121) = 0.19$, $p = .83$; Wilks' $\lambda = 1.00$. Hence, hypotheses 1, 2, 3, and 4 are not confirmed.

Table 1. *MANOVA table with effects for Lying, Cognitive Load, and Stage on AOI 1 and AOI 2.*

		F (2, 121)	*p*	*λ*
Total fixation duration	Lying	0.28	.76	1.00
	Cognitive Load	0.27	.76	1.00
	Stage	46.72	.00	0.56
	Stage * Lying	1.44	.24	0.98
	Stage * Cognitive Load	0.03	.98	1.00
	Lying * Cognitive Load	0.07	.93	1.00
	Stage * Lying * Cognitive Load	0.24	.79	1.00
Fixation count	Lying	0.24	.79	1.00
	Cognitive Load	0.30	.74	1.00
	Stage	44.56	.00	0.58
	Stage * Lying	1.76	.18	0.97
	Stage * Cognitive Load	0.09	.92	1.00
	Lying * Cognitive Load	0.09	.92	1.00
	Stage * Lying * Cognitive Load	0.19	.83	1.00

Post-experiment questionnaire

As mentioned in the method section, two variables, perceived cognitive state and perceived cognitive load, were found reliable to use. The third variable, perceived gaze behavior, with a strong correlation between the two measured statements, was taken into account in order to get an idea about how the participants perceived AOI 1 and AOI 2. Table 2 shows the descriptive statistics, mean and standard deviation, of all variables for Lying and Cognitive Load. A one-way MANOVA test has been conducted on perceived cognitive state, perceived cognitive load, and perceived gaze behavior for Lying and Cognitive Load.

The results showed a statistically significant main effect for Lying on perceived cognitive state, perceived cognitive load, and perceived gaze behavior as a group, $F(3, 120) = 14.90$, $p < .01$; Wilks' $\lambda = 0.73$. Univariate analyses revealed that perceived cognitive state was significantly higher for liars ($M = 3.28$, $SD = 0.46$) than for truth tellers ($M = 2.74$, $SD = 0.48$), $F(1, 122) = 41.56$, $p < .01$. No statistically significant effect was found on perceived cognitive load, $F(1, 122) = 1.64$, $p = .20$, and perceived gaze behavior, $F(1, 122) = 0.01$, $p = .98$. Further, the results showed that there was no statistically significant main effect found for Cognitive Load on perceived cognitive state, perceived cognitive load, and perceived gaze behavior as a group, $F(3, 120) = 0.83$, $p = .48$; $\lambda = 0.98$. Also, there was no statistically significant interaction effect found between Lying and Cognitive Load, $F(3, 120) = 1.51$, $p = .22$; $\lambda = 0.96$. However, when looking into the pairwise comparisons between liars and truth tellers, it appeared that for perceived cognitive load, liars with high Cognitive Load ($M = 2.98$, $SD = 0.12$) experienced significantly more cognitive load ($p = .04$) during the experiment than truth tellers with high Cognitive Load ($M = 2.63$, $SD = 0.13$).

Table 2. *Descriptive Statistics of the variables perceived cognitive state, perceived cognitive load, and perceived gaze behavior for Lying and Cognitive Load.*

			Cognitive Load					
			Low		High		Total	
			M	*SD*	*M*	*SD*	*M*	*SD*
Perceived cognitive state	Lying	No	2.68	0.48	2.79	0.49	2.74	0.48
		Yes	3.29	0.46	3.28	0.47	3.28	0.46
		Total	2.98	0.56	3.04	0.54		
Perceived cognitive load	Lying	No	2.85	0.62	2.63	0.79	2.74	0.72
		Yes	2.83	0.72	2.98	0.74	2.91	0.73
		Total	2.84	0.67	2.81	0.78		
Perceived gaze behavior	Lying	No	2.18	0.92	1.91	0.77	2.04	0.85
		Yes	2.07	0.78	2.01	0.50	2.04	0.64
		Total	2.13	0.85	1.96	0.64		

Explorative areas of interest

It is expected that liars avoid gazing at the eyes of the interrogator and at their self-image. Consequently, they must be gazing at other areas. When conducting the experiment, it was notable that participants were also gazing at the mouth and bottom part of the nose of the interrogator, as well as to areas beyond the interrogator. Hence, there have also been made AOIs in Tobii Pro Lab on these areas in order to test hypothesis 1, 2, 3, and 4 as substitute hypotheses on these AOIs, but then for substitute hypothesis 1 and 2 the other way around (i.e. whether liars will gaze more instead of less at these AOIs than truth tellers). The AOIs were created on the mouth and nose of the interrogator (AOI 3, see figure 6) for substitute hypothesis 1 and 3 and on the total screen minus the face of the interrogator and minus the participant's self-image (AOI 4, see figure 7) for substitute hypothesis 2 and 4. All hypotheses were again analyzed by means of 2 (Lying: yes vs. no) x 2 (Cognitive Load: high vs. low) x 2 (Stage: baseline vs. experiment) repeated measures MANOVA tests. The results are displayed in table 3.

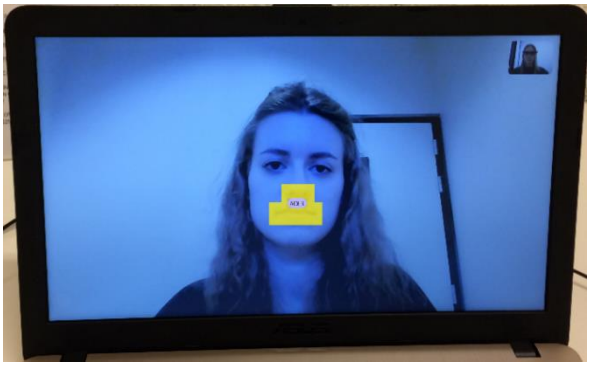

Figure 6. AOI 3 (yellow)

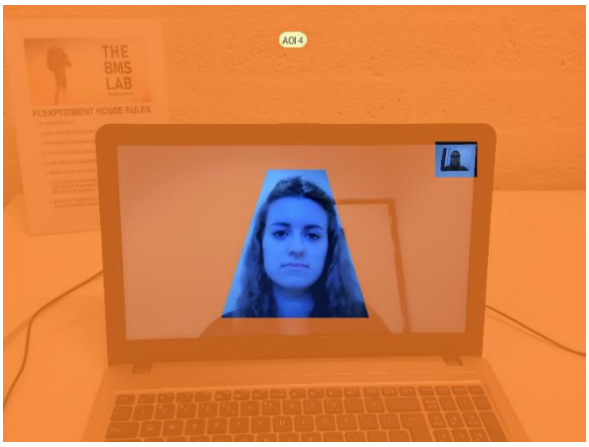

Figure 7. AOI 4 (orange)

Table 3. *MANOVA table with effects for Lying, Cognitive Load, and Stage on AOI 3 and AOI 4.*

		F (2, 121)	*p*	*λ*
Total fixation duration	Lying	1.48	.23	0.98
	Cognitive Load	0.18	.84	1.00
	Stage	18.71	.00	0.76
	Stage * Lying	1.64	.20	0.97
	Stage * Cognitive Load	0.42	.66	0.99
	Lying * Cognitive Load	1.35	.26	0.98
	Stage * Lying * Cognitive Load	3.39	.04	0.95
Fixation count	Lying	3.04	.05	0.95
	Cognitive Load	0.56	.57	0.99
	Stage	22.20	.00	0.73
	Stage * Lying	1.06	.35	0.98
	Stage * Cognitive Load	1.21	.30	0.98
	Lying * Cognitive Load	1.89	.16	0.97
	Stage * Lying * Cognitive Load	2.04	.13	0.97

Total fixation duration

A repeated measures MANOVA test analyzed total fixation duration (in seconds) on both AOI 3 and AOI 4 for Lying and Cognitive Load over both Stages. The results showed that there was no statistically significant main effect for Lying on AOI 3 and AOI 4, $F(2, 121) = 1.48$, $p = .23$; Wilks' $\lambda = 0.98$, and for Cognitive Load on AOI 3 and AOI 4, $F(2, 121) = 0.18$, $p = .84$; Wilks' $\lambda = 1.00$. However, there was a statistically significant main effect for

Stage on AOI 3 and AOI 4 as a group, $F(2, 121) = 18.71$, $p < .01$; Wilks' $\lambda = 0.76$. Univariate analyses revealed that participants' total fixation duration on both AOI 3, $F(1, 122) = 35.90$, $p < .01$, and AOI 4, $F(1, 122) = 6.30$, $p = .01$, was significantly longer in the experimental Stage (AOI 3: $M = 25.19$, $SD = 18.62$; AOI 4: $M = 12.57$, $SD = 12.90$) than in the baseline Stage (AOI 3: $M = 18.75$, $SD = 12.61$; AOI 4: $M = 10.44$, $SD = 9.45$).

Further, there was no statistically significant interaction effect between Lying and Stage on AOI 3 and AOI 4, $F(2, 121) = 1.64$, $p = .20$; Wilks' $\lambda = 0.97$, between Cognitive Load and Stage on AOI 3 and AOI 4, $F(2, 121) = 0.42$, $p = .66$; Wilks' $\lambda = 0.99$, and between Lying and Cognitive load on AOI 3 and AOI 4, $F(2, 121) = 1.35$, $p = .26$; Wilks' $\lambda = 0.98$. A statistically significant interaction effect was found between Lying, Cognitive Load, and Stage on AOI 3 and AOI 4 as a group, $F(2, 121) = 3.39$, $p = .04$; Wilks' $\lambda = 0.95$. Pairwise comparisons between liars and truth tellers revealed that for AOI 4, total fixation duration in the experimental Stage was significantly longer ($p = .01$) for truth tellers with high Cognitive Load ($M = 16.60$, $SD = 2.24$) than for liars with high Cognitive Load ($M = 8.36$, $SD = 2.18$). Pairwise comparisons between the baseline and experimental Stage revealed that for AOI 3, total fixation duration was significantly longer in the experimental Stage compared to the baseline Stage for liars with high Cognitive Load ($p < .01$; experimental: $M = 27.09$, $SD = 3.22$; baseline: $M = 19.34$, $SD = 2.15$), for truth tellers with high Cognitive Load ($p < .01$; experimental: $M = 22.46$, $SD = 3.31$; baseline: $M = 15.85$, $SD = 2.22$), and for truth tellers with low Cognitive Load ($p < .01$; experimental: $M = 26.62$, $SD = 3.42$; baseline: $M = 17.92$, $SD = 2.29$). For AOI 4, total fixation duration for truth tellers with high Cognitive Load was significantly longer ($p = .01$) in the experimental Stage ($M = 16.60$, $SD = 2.24$) compared to the baseline Stage ($M = 11.95$, $SD = 1.68$).

Fixation count

A repeated measures MANOVA test analyzed fixation count on both AOI 3 and AOI 4 for Lying and Cognitive Load over both Stages. The results showed that there was a close to statistically significant main effect for Lying on AOI 3 and AOI 4 as a group, $F(2, 121) = 3.04$, $p = .05$; Wilks' $\lambda = 0.95$. Univariate analyses revealed that for AOI 3, fixation count in both baseline and experimental Stage was significantly higher for liars (baseline: $M = 44.61$, $SD = 23.76$; experimental: $M = 56.38$, $SD = 35.25$) than for truth tellers (baseline: $M = 34.55$, $SD = 20.19$; experimental: $M = 48.68$, $SD = 26.55$), $F(1, 122) = 3.78$, $p = .05$. However, for AOI 4, fixation count in both baseline and experimental Stage was higher (yet not significant) for truth tellers (baseline: $M = 50.02$, $SD = 35.14$; experimental: $M = 60.90$, $SD = 44.89$) than for liars (baseline: $M = 42.92$, $SD = 33.54$; experimental: $M = 44.50$, $SD = 46.81$), $F(1, 122) = 3.01$, $p = .09$. Further, no statistically significant main effect was found for Cognitive Load on AOI 3 and AOI 4, $F(2, 121) = 0.56$, $p = .57$; Wilks' $\lambda = 0.99$. For Stage, again a statistically significant main effect was found on AOI 3 and AOI 4 as a group, $F(2, 121) = 22.20$, $p < .01$; Wilks' $\lambda = 0.73$. Univariate analyses revealed that fixation count on both AOI 3, $F(1, 122) = 44.00$, $p < .01$, and AOI 4, $F(1, 122) = 4.09$, $p = .05$, was significantly higher in the experimental Stage (AOI 3: $M = 52.59$, $SD = 31.39$; AOI 4: $M = 52.57$, $SD = 46.43$) than in the baseline Stage (AOI 3: $M = 39.66$, $SD = 22.56$; AOI 4: $M = 46.41$, $SD = 34.39$).

Further, there was no statistically significant interaction effect between Lying and Stage on AOI 3 and AOI 4, $F(2, 121) = 1.06$, $p = .35$; Wilks' $\lambda = 0.98$, between Cognitive Load and Stage on AOI 3 and AOI 4, $F(2, 121) = 1.21$, $p = .30$; Wilks' $\lambda = 0.98$, and between Lying and Cognitive load on AOI 3 and AOI 4, $F(2, 121) = 1.89$, $p = .16$; Wilks' $\lambda = 0.97$. A close to statistically significant interaction effect was found between Lying, Cognitive Load, and Stage on AOI 3 and AOI 4, $F(2, 121) = 2.04$, $p = .13$; Wilks' $\lambda = 0.97$. Pairwise comparisons between liars and truth tellers revealed that for AOI 3, fixation count was (close

to) significantly higher for liars with high Cognitive Load than for truth tellers with high Cognitive Load in both baseline Stage (p = .04; liars: M = 46.85, SD = 3.81; truth tellers: M = 35.28, SD = 3.92) and experimental Stage (p = .06; liars: M = 62.85, SD = 5.34; truth tellers: M = 48.06, SD = 5.50). However, fixation count on AOI 4 was (close to) significantly higher for truth tellers with high Cognitive Load than for liars with high Cognitive Load in both baseline Stage (p = .08; liars: M = 40.53, SD = 5.89; truth tellers: M = 55.28, SD = 6.07) and experimental Stage (p = .01; liars: M = 35.47, SD = 7.82; truth tellers: M = 65.78, SD = 8.06). Overall, for the explorative areas of interest, substitute hypothesis 1 can be confirmed with caution. However, the other substitute hypotheses are not confirmed.

Discussion

The aim of this study was to explore whether it is possible to use eye tracking technology in differentiating liars from truth tellers in interrogation settings. Based on participants' eye movements, it was examined whether liars would make less eye contact with the interrogator and would spend less time glancing at their self-image compared to truth tellers. Further, cognitive load was manipulated in order to find out whether these effects would become stronger.

Lying

In contrast to what was expected in hypothesis 1, liars did not make significantly less (or more) eye contact with the interrogator than truth tellers. These findings contradict theory in which was stated that liars avoid eye contact due to cognitive load and feelings of guilt or fear (Vrij et al., 2010; DePaulo & Rosenthal, 1981). However, the findings are in line with the findings of Sporer and Schwandt (2007) and DePaulo et al. (2003) that the relationship between eye contact and deception is found to be quite weak or even non-existent. According

to theory, liars who are motivated to make the lie succeed make less eye contact than liars who are less motivated and truth tellers (DePaulo et al., 2003). It could be that in the current study's experiment, liars were not that motivated to make the lie succeed and could, therefore, not be distinguished from truth tellers regarding eye contact. Therefore, hypothesis 1 was not confirmed. Later on, the issue of motivation will be discussed further.

When examining hypothesis 2, it appears that the results were again in contrast to what was expected. Liars did not glance significantly less (or more) at their self-image than truth tellers. Research suggests when watching their self-image, liars become more self-aware because they are being confronted with their own lying behavior which leads to increased tension and, therefore, impedes deception (Lawson et al., 2013; DePaulo et al., 2003). However, the frame of the self-image in Skype was quite small (see figure 5, 6, and 7). Therefore, participants might not have been able to watch their own behavior properly which might explain why it was found that liars did not significantly glance less at their self-image than truth tellers. Therefore, hypothesis 2 was not confirmed.

Cognitive Load

When manipulating Cognitive Load, the difference between liars and truth tellers regarding eye contact and glancing at their self-image did not significantly increase. According to the cognitive load approach, it is cognitively more demanding to lie than to tell the truth which might lead to showing cues to deception when lying (Vrij et al., 2006; Vrij et al., 2010; Vrij et al., 2011; Vrij & Granhag, 2012). Furthermore, when increasing this cognitive load, these behavioral differences between liars and truth tellers might become even more clear (Vrij & Granhag, 2012). However, the results on hypothesis 3 and 4 showed no significant differences between liars and truth tellers when Cognitive Load was manipulated with a secondary task.

Also, when taking a look at the results of the perceived cognitive load variable from the post-experiment questionnaire, it was measured that participants who had to lie did not experience significantly more cognitive load than participants who told the truth. This contradicts the cognitive load approach. A possible explanation might be that liars received rather unconfined instructions to answer all questions with a lie. Therefore, they were free to give their own twist to the lies. This might have led to liars telling lies which contained a white lie character. In general, people tell white lies on daily basis to protect others' feelings or to protect one's own expenses in situations in which there is not much at stake for the person telling the lies (Erat & Gneezy, 2012; Rigoulot, Fish & Pell, 2014; Griffith, Lee, Peterson & Zickar, 2011). Due to the daily use of white lies, people are well trained in credibly transmitting these lies to other persons. Therefore, it makes it difficult to distinguish the liars from the truth tellers (DePaulo, 2003; Rigoulot, Fish & Pell, 2014). The lies told in the current research might have had a nature of white lies in which there was not much at stake for the participants. Liars might just have changed small details in their story. According to theory, this does not require more mental effort than telling the truth (Vrij et al., 2000; Sporer & Schwandt, 2007). This might have led to liars not experiencing more cognitive load than truth tellers during the experiment.

However, when manipulating Cognitive Load, perceived cognitive load became significantly higher for liars than for truth tellers. In contrast to the results on hypothesis 3 and 4, this is in line with the cognitive load approach. So, for perceived cognitive load, the Cognitive Load manipulation did have positive effects. However, for hypothesis 3 and 4, the manipulation did not result in what was expected. Therefore, hypothesis 3 and 4 were not confirmed.

Besides perceived cognitive load, it was also examined in the post-experiment questionnaire whether liars felt more tense and nervous than truth tellers (i.e. the perceived

cognitive state variable). It was found that liars indeed felt more tense and nervous than truth tellers, also when Cognitive Load was manipulated. The attempted control approach argues that liars attempt to appear credible and hide any leakage of cues to deception by controlling their behavior. Research shows that deliberately controlling one's own behavior can cause tension and nervousness (DePaulo et al., 2003; Sporer & Schwandt, 2007; Vrij, Semin, & Bull, 1996). This in combination with the fact that the participants were told that they had to watch a crime and would be interrogated by a police officer afterwards, might be the reason that participants who had to lie indicated that they experienced a higher perceived cognitive state than truth tellers.

Explorative areas of interest

Further, explorative analyses have been conducted on other areas of interest. It was examined whether liars gazed more than truth tellers at the mouth and the bottom part of the nose of the interrogator and the area beyond the interrogator as substitute hypothesis 1 and 2, and whether these effects would become stronger when Cognitive Load was manipulated as substitute hypothesis 3 and 4. First, it was found that in multiple aspects total fixation duration and fixation count on these areas of interest were higher in the experimental Stage compared to the baseline Stage. This can be explained by the fact that the average duration of the experimental Stage was longer than the average duration of the baseline Stage. Therefore, participants were able to gaze for a longer period of time to the areas of interest. Second, results on the area of interest of the mouth and nose of the interrogator supported the substitute hypothesis 1 that liars gazed more at this area of interest compared to truth tellers. However, this difference was on a close to significant level, therefore, interpretation must be handled with caution.

In contrast to substitute hypothesis 1, the results on the area of interest of the area beyond the interrogator contradict substitute hypothesis 2 that liars gazed more at this area of interest as well. The results showed the opposite, namely, that truth tellers gazed more at the area beyond the interrogator than liars. According to theory, gaze aversion improves answering moderately difficult questions associated with remembering because it suppresses visual environmental, attention attracting, stimulations (e.g. another person). Averting gaze from these stimulations facilitates diversion of cognitive resources toward remembering (Glenberg, Schroeder & Robertson, 1998; Doherty-Sneddon & Phelps, 2005). Applied to substitute hypothesis 2, truth tellers needed to remember information from the video of the crime in order to answer the interrogation questions correctly. This is in contrast with liars who could forge any answer they wanted because they did not need to remember actual true information. Therefore, truth tellers averted their gaze from the visual, attention attracting interrogator and gazed more at the area beyond the interrogator in order to better recall the asked information. So, liars did not gaze more at the area of interest beyond the interrogator than truth tellers. Therefore, substitute hypothesis 2 was not confirmed.

Third, when manipulating Cognitive Load with a secondary task, the difference between liars and truth tellers regarding glancing at the mouth and the bottom part of the nose of the interrogator and the area beyond the interrogator did not significantly increase. Therefore, substitute hypothesis 3 and 4 were not confirmed.

Motivation

Next, returning to the topic of motivation, the motivation to be convincing with the lies might have been relatively low. First, participants knew beforehand that they participated in an experiment. Therefore, no strings were attached. Before conducting the experiment, this was already expected to be little motivating. Therefore, several means of motivation were

implemented in an attempt to motivate participants somehow, as described in the paragraph 'Procedure'. It might be possible that despite these attempts participants were still not motivated enough.

Second, the participants were watching the committed crime in a video instead of in real life. In an attempt to make it as real as possible, participants were instructed to try envision that the video was not a video but a real life situation and that they were physically present in the store of the gas station. Some of the participants mentioned during the debriefing of the experiment that they had a hard time imagining themselves being physically present in the store. Further, participants in the lying condition were instructed to envision the person in the video who was committing the crime as their good friend who had asked them to lie against the police in order to protect him. However, in real life, the person committing the crime was not a familiar person to the participants. It was mentioned by some participants that they found it difficult to imagine this person as their good friend. Therefore, despite the attempts to make participants imagine that the video is not a video and that the person committing the crime is their good friend, the motivation to lie might be relatively low compared to a real life situation when the person committing the crime would have been an actual good friend.

Third, participants were lying for another person (i.e. other-oriented) and not for themselves (i.e. self-serving). In the set-up of the experiment, it was deliberately chosen to make participants lie for another person, their so-called good friend, instead of for themselves. The reason for this is that in the video of the committed crime, participants see another person committing the armed robbery. It was expected that participants might found it difficult to imagine that they would symbolize this person because, first, they do not look alike and might not even have the same gender as this person and, second, they would then be watching themselves committing a currently happening crime in a gas station while meanwhile they

were sitting in a chair in front of a laptop in a different building than the gas station. Therefore, it was expected that it would make more sense if the participants had to imagine the person committing the crime not to be themselves but someone else; their good friend in this case. However, then they were lying for someone else and not for themselves which might have made participants less motivated to be convincing with their lies. When a lie might not be convincing enough for the interrogator, it would not matter that much because it would not incriminate themselves but only their supposedly good friend. There were no consequences for their actions.

The three above-mentioned reasons for motivation might explain why the differences between liars and truth tellers were found not significant in the current study. In the experiment of this study, an attempt has been made to motivate the participants as much as possible. The results of the post-experiment questionnaire have shown that liars experienced higher levels of perceived cognitive state compared to truth tellers. However, this does not mean that liars were more motivated than truth tellers. In this study, the degree of participants' motivation has not been measured. In future research, it would be recommended to measure the degree of participants' motivation during the experiment. For example, by a self-report questionnaire. Further, to make participants more motivated to take part in the experiment, a real life setting of the crime video in which participants have to make self-serving lies might expand participants' imagination. However, real life settings also come with uncontrollable factors. Therefore, in this study, a video has been used. In future research, it would be advised to find the right balance between a lab setting and a real life setting in order to motivate participants enough and obtain the optimum results.

Skype

Also not entirely real life is the used communication medium Skype. Skype is an indirect and digital form of communication. The interrogator was not physically present in the same room as the participants. The participants were interrogated by a digital version of the interrogator via the screen of the laptop. According to the social distance theory, people are more likely to lie in settings where a social distance can be maintained. For example, people are more likely to lie via indirect settings as text-messaging than in direct face-to-face settings (Whitty, Buchanan, Joinson & Meredith, 2011). Skype is a sort of face-to-face setting, but then digital in which a social distance still can be maintained and is, therefore, less direct and less intense than a real life face-to-face setting. Therefore, participants might have found it less hard to lie because of the social distance between them and the interrogator which might explain why the differences between liars and truth tellers were not significant.

Further, the frame of the self-image in Skype was quite small as described previously. Also, there were some participants who did not yet had experience with Skype or did not even know what Skype was. Therefore, besides the written instructions, extra verbal instructions were made to all participants during the experiment before each Skype interrogation. In these verbal instructions, the written instructions were repeated shortly, but also the Skype interface was explained. Nevertheless, during the debriefing of the experiment, some participants claimed that they had not noticed the frame of their self-image. This might be due to the fact that the frame of the self-image was small and that, therefore, participants could not see themselves clearly. This might be a reason why the difference between liars and truth tellers regarding glancing at their self-image were not significant.

The choice to use Skype as communication medium was made with a reason. It was a live conversation with both the self-image and the eyes of the interrogator in one static interface. In this way, it was controlled for dynamic frames. Tobii Pro Lab could implement

the data of the Tobii eye trackers onto one snapshot with both the self-image and the eyes of the interrogator recognized as static frames. A real life face-to-face interrogation would make it more direct and more intense and would probably make participants more motivated. Also, adding an actual mirror, or something in which participants can see themselves more life-sized and more clearly, would lead to participants being able to watch their behaviors more properly. However, such real life settings also come with uncontrollable factors. Therefore, in this study, it has been decided to use Skype as interrogation medium. For a follow-up study, it would be advised to find the right balance between a lab setting and a real life setting in which participants will be sufficiently motivated in order to obtain the best possible results.

Conclusion

In conclusion, an answer will be given to the research question: *To what extent can eye tracking technology be used in differentiating liars from truth tellers in interrogation settings?* In the current study, there was insufficient evidence found to support the hypotheses. With the current setup of the experiment, eye tracking technology could not differentiate liars from truth tellers in interrogation settings. Hence, the main recommendation will be to make the experiment more realistic and more direct in order to make participants more motivated to participate intensively. Further, it will be advised to experiment with other types of increasing cognitive load as well as to make use of various settings, besides the criminal investigation setting which was used in the current study, to explore whether other effects arise. Despite the not confirmed hypotheses, the current study provides a basis for future research on eye tracking technology in which more can be learned about differentiating liars from truth tellers with regard to cues to deception in the eyes.

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Appendix A

Informed consent

University of Twente
Faculty Psychology; Conflict, Risk, & Safety
Drienerlolaan 5
7522 NB Enschede

Dear participant,

You indicated to participate in the research to gender differences between eye witness' recall memory. This research guided by Mr. P. W. de Vries will be carried out by student Branda Wolters in the context of the study Psychology at the University of Twente. The researcher does not know anything about the research, she just executes it. The purpose of the research is not to judge the behavior of the participants but to analyze it in order to make clear the difference between men and women in various situations.

In this research, the differences in behavior between men and women will be looked into. The obtained data will be examined for the purpose of the research. Therefore, you will be wearing eye tracking glasses which will record your eye movements. The recordings will only be used for academic purposes and will be anonymous. Hence, we will request your permission to record. If you disagree, you can notify the researcher.

Participation to this research is completely voluntarily. All data will be processed anonymously and will only be used for academic purposes. At any time, you can stop the research and withdraw this informed consent. For questions afterwards, you can ask the researcher.

I read this form and I agree,

…….. ……..
Date Signature participant

Appendix B

B.1 Introduction form for informed consent

Thank you for your participation in the research on *gender differences in eye witnesses' recall memory*. The purpose of this research is to gain insight into the differences between men and women when they try to recall information from their memory. It operates also as an interrogation training for police officers.

The eye tracking glasses will record your eye movements during the process. Also, audio recordings will be made. This data will be used for academic purposes only. If you disagree, you can notify the researcher.

B.2 Introduction form for baseline video

In a minute, a video of wildlife animals will be shown to you. Try to remember as many details as possible. After watching the video, a police officer will ask you a couple of questions in response to the video. This questioning will take place via the video chat platform Skype. Your answer to each question cannot be wrong or right, it is your own answer.

Appendix C

Introduction form for lying condition

Up next, a video of a crime in a store will be shown to you. Again, try to remember as much details as possible. Imagine that you are shopping in this store and at the same time, your good friend enters the store and commits the crime. You are an eye witness to this crime. After watching the crime, the police officer will again ask you a couple of questions in response to the crime. Your answer cannot be wrong or right, it is your own answer.

Your good friend asked you to protect him from the police by lying for him during the interrogation. Answer every question with a lie and make sure that your friend does not look guilty. The police officer has not seen the crime nor the video and is, therefore, not aware of the events you have witnessed. Hence, it is important that you try your best to be convincing with the lies you tell and make sure that the police officer does not notice that you are lying. If you can convince the police officer of your lies, you stand a chance of winning a smartwatch!

Recap (displayed after watching video)**:**

- Answer all questions with a lie.
- Your close friend needs protection from the police.
- Be convincing in deceiving the police officer.

Appendix D

Introduction form for lying condition with manipulation

Up next, a video of a crime in a store will be shown to you. Again, try to remember as much details as possible. Imagine that you are shopping in this store and at the same time, your good friend enters the store and commits the crime. You are an eye witness to this crime. After watching the crime, the police officer will again ask you a couple of questions in response to the crime. Your answer cannot be wrong or right, it is your own answer.

Your good friend asked you to protect him from the police by lying for him during the interrogation. Answer every question with a lie and make sure that your friend does not look guilty. Do this without mentioning filler words as '*uh*' or '*um*'. The police officer has not seen the crime nor the video and is, therefore, not aware of the events you have witnessed. Hence, it is important that you try your best to be convincing with the lies you tell and make sure that the police officer does not notice that you are lying. If you can convince the police officer of your lies, you stand a chance of winning a smartwatch!

Recap (displayed after watching video)**:**

- Answer all questions with a lie.
- Your close friend needs protection from the police.
- Do not mention filler words as '*uh*' or '*um*' out loud.
- Be convincing in deceiving the police officer.

Appendix E

Introduction form for truth telling condition

Up next, a video of a crime in a store will be shown to you. Again, try to remember as much details as possible. Imagine that you are shopping in this store and at the same time, someone enters the store and commits the crime. You are an eye witness to this crime. After watching the crime, the police officer will again ask you a couple of questions in response to the crime. The police officer has not seen the crime nor the video and is, therefore, not aware of the events you have witnessed. Your answer cannot be wrong or right, it is your own answer. Just try to answer the questions as honest as possible. If you do not know an answer to a question, do not make up an answer but still be honest by answering that you just do not know.

Recap (displayed after watching video)**:**

- Answer all question with the truth.
- There are no wrong or right answers.
- If you do not know the answer, just honestly say that you do not know.

Appendix F

Introduction form for truth telling condition with manipulation

Up next, a video of a crime in a store will be shown to you. Again, try to remember as much details as possible. Imagine that you are shopping in this store and at the same time, someone enters the store and commits the crime. You are an eye witness to this crime. After watching the crime, the police officer will again ask you a couple of questions in response to the crime. The police officer has not seen the crime nor the video and is, therefore, not aware of the events you have witnessed. Your answer cannot be wrong or right, it is your own answer. Just try to answer the questions as honest as possible and do this without mentioning filler words as '*uh*' or '*um*'. If you do not know an answer to a question, do not make up an answer but still be honest by answering that you just do not know.

Recap (displayed after watching video)**:**

- Answer all question with the truth.
- There are no wrong or right answers.
- Do not mention filler words as '*uh*' or '*um*' out loud.
- If you do not know the answer, just honestly say that you do not know.

Appendix G

Interrogation questions baseline video:

- What do you think of the video you just watched?
- Which feelings did you experience? (e.g. happiness, relaxation)
- In what kind of environment did the video take place?
- Which animals did you see?
- Did you only see grown up animals or did you see baby animals as well?
- What were these animals doing?
- Did you hear them make noises?
- What did you think of the music that was playing?

Appendix H

Interrogation questions crime video:

General questions

- What do you think of the crime you just witnessed?
- Which feelings did you experience? (e.g. excitement, anxiety)

Specific questions

- In what kind of store were you?
- According to the language, in which country was the store located?
- How many persons were committing the crime?
- Do you know this person?
- Can you describe the appearance of this person?
- What was he doing exactly?
    - When not told: Did he use some kind of weapon?
    - When told: If I recall correctly, he did (not) use a weapon?
- What did he take from the store?
- What were you doing in the store?
- What did the woman behind the counter do?

Appendix I

Post-experiment questionnaire

A questionnaire with a 5-point Likert scale (*completely disagree - completely agree*) consisting of 15 items measuring Perceived Cognitive State (PCS), Perceived Gaze Behavior (PGB) and Perceived Cognitive Load (PCL).

During the last interrogation…

1. … I felt tense.	**PCS**
2. … I felt being watched.	**PCS**
3. … I tried to hide my nerves.	**PCS**
4. … I tried to hide my emotions.	**PCS**
5. … I tried to act as normal as possible.	**PCS**
6. … I tried to describe as less emotions as possible.	**PCS**
7. … I tried to not correct myself when I said something wrong.	**PCS**
8. … I repeated (parts of) a question to buy myself time to answer the question.	**PCS**
9. … I tried to avoid looking into the interrogator's eyes.	**PGB**
10. … I tried to avoid looking at the frame of my self-image in Skype.	**PGB**
11. … I really needed to concentrate.	**PCL**
12. … I had to think hard about the answers to the questions.	**PCL**
13. … I needed to remember a lot.	**PCL**
14. The experiment took a lot of mental effort.	**PCL**
15. I experienced the interrogation as cognitively demanding.	**PCL**