Eye-tracking technology in combination with the Guilty Knowledge Test in police investigations

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“Where words are restrained, the eyes often talk a great deal.”

Samuel Richardson

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Abstract

The current research examined whether people who are in the possession of guilty knowledge differ in their eye-movement patterns (i.e. total fixation duration and fixation count) in comparison to innocent people who are not in the possession of guilty knowledge. This study also took the first step in involving accomplices and in investigating whether accomplices show different eye-movements in comparison to guilty- and innocent suspects. The design of the study was a between-subjects design with three conditions: guilty condition, accomplice condition, and control condition. Participants imagined that they either were guilty of hiding synthetic drugs, were an accomplice of hiding synthetic drugs in exchange for 10.000 euro, or did not have guilty knowledge (control condition). Then, participants were shown a picture of the crime scene during an interrogation, where the guilty- and accomplice conditions were asked to lie and the control condition was asked to tell the truth. While participants looked at the picture, their eye-movements were tracked. The results of the current study show no statistical differences between the conditions, which implies that guilty people (perpetrators and accomplices) and innocent people do not differ in their eye-movement patterns. This study also revealed other valuable insights for future research. It contributes in emphasizing the importance of using a strong manipulation during experiments, the involvement of participants, and sample size, which should all be taken into account for in future research.

Keywords: Eye-movement, eye-tracking, fixations, Guilty Knowledge Test, deception

Introduction

"Kirk Bloodsworth, a former Marine who had become a waterman on the Eastern Shore of Maryland, was the first person to be sentenced to death and then subsequently exonerated. He was 22-years-old at the time of his wrongful conviction and served nine years in prison before he was released."

Legal literature originating from the beginning of the century, along with literature of more recent studies, provide us with more cases like Kirk Bloodsworth. Innocent men and women who are being convicted of serious crimes that they did not commit (Rattner, 1988). This indicates that the judicial system has flaws that can lead to the wrongful conviction of innocent suspects. In order to reduce the amount of wrongful convictions, researchers are seeking ways to improve the accuracy of discriminating between innocent- and guilty suspects (Kassin, 2008). Still, discriminating between deceivers and truth-tellers may be more difficult than initially thought.

Deception is a fundamental aspect of human behaviour that is likely to have emerged in the early human evolutionary history (Porter & ten Brinke, 2010). Deception can be defined as 'the act of deliberately providing or omitting information with the intention of misleading' (Hahm, Ji, Jeong, Oh, Kim, Sim, & Lee, 2009, p.269). Extensive research has been done in trying to detect cues of deception (Levine, 2018; Nahari, Breska, Elber, Klein Selle, & Ben-Shakhar, 2017). However, when people are actively asked to discriminate between truth and deception, their performance range generally falls into the 45-60% range (Vrij, Akehurst, & Knight, 2006; Mann, Vrij, & Bull, 2004; Vrij, 2000; Kraut, 1980). In addition to this, it seems that police officers are not much better at discriminating between liars and truth-tellers and scored around the same accuracy rate as college students (around 55%) (Mann et al., 2004; Ben-Shakhar & Elaad, 2003). Though the human ability to detect lies is low, since long before, several methods have been developed to try and discriminate between deception and truth-telling, like the Guilty Knowledge Test (GKT) or also known as the Concealed Information Test (Ben-Shakhar & Elaad, 2002; Iacono, 2011).

The GKT is a largely researched lie detection method which is based on solid scientific principles revolving around physiological responses (Elaad, 2009; Engelhard, Merkelbach, & van den Hout, 2003), and is attractive method for forensic applications (Ben-Shakhar & Elaad, 2002). The topic of this research focuses on detecting high-stakes deception, meaning that if one would discover the truth, an undesirable penalty awaits the guilty suspect (Twyman, Elkins, & Burgoon, 2011), like being sentenced to prison. For this reason, the principles of the GKT

will be used in this study. The idea behind the test is that perpetrators that have committed a crime, in contrast to innocent people, have specific knowledge about this crime. It is therefore expected that someone with guilty knowledge will show a stronger physiological response towards the correct item. The recording of the physiological responses is typically measured through skin conductance, heart rate, respiration line length, and finger pulse waveform length (Engelhard, et al., 2003; Volz, Bahr, Heinrichs, Vaitl, & Ambach, 2018). When a stronger response is measured, it is inferred that this person has knowledge of the event (Engelhard et al., 2003; Elaad, 2009).

Thus, the GKT attempts to examine whether suspects are in the possession of guilty knowledge (Jang, Kim, Cho, & Lee, 2013), and consists out of various multiple choice questions with different items about crime-details. Among these items, there is one 'guilty knowledge' item present, in combination with incorrect alternatives. It is critical here that all items are equally plausible to someone who is innocent (Engelhard et al., 2003; Elaad, 2009; Iacono, 2011; MacLaren, 2001). For instance, when suspects are given the question: 'How did the murderer kill the victim? Did he use a: (1) hammer; (2) gun; (3) belt; (4) knife?' It is assumed that the suspect with guilty knowledge recognizes the correct answer, which then produces a (physiological) orienting response, whereas an innocent suspect would not recognize the correct answer and would not produce such a response (Vrij & Fisher, 2016; Ben-Shakhar & Elaad, 2002; MacLaren, 2001).

Also, the GKT has high accuracy rates of classifying guilty- and, especially, innocent suspects (Ben-Shakhar & Furedy, 1990). Aside from the GKT, that uses the physiological responses as an indicator, new techniques to detect deception are being actively developed nowadays. For instance, various research has been done in combining the GKT with eye-tracking technology (Derrick, Moffitt, and Nunamaker, 2011; Peth, Kim and Gamer, 2013; Kovalev, Luniakova, and Menshikova, 2016). The results of these studies show that the accuracy rates in discriminating between people who are truthful and people who are deceitful increase when combining the GKT with eye-tracking. Therefore, the current study will research whether people who possess guilty knowledge differ in their eye-movement patterns, regarding their total fixation duration and fixation count, in comparison to people who do not possess guilty knowledge. For this reason, the theory behind the GKT and eye-tracking will be further described.

Guilty Knowledge Test

The GKT is a well-validated tool for detecting concealed knowledge (Klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2017). As has been described before, it is assumed that when one has guilty knowledge, he or she will show a stronger physiological response towards the correct item in the multiple choice question (Engelhard et al., 2003; Elaad, 2009). This enhanced physiological response to the crime-related item is based on the orienting response. The orienting response can be defined as the physiological, cognitive, and behavioural response that is drawn out by a novel or personally significant stimulus (Volz, Bahr, Heinrichs, Vaitl, & Ambach, 2018). For instance, when a suspect is confronted with various equally plausible items in the GKT, it is assumed that the correct item has a special meaning to the guilty suspect, and this person will show an enhanced psychophysiological response towards this item (Verschuere, Crombez, & Koster, 2004). Thus, the orienting reflex is the active mechanism underlying the enhanced response that is brought out by this item (Elaad, 2009). Since the orienting reflex is autonomic, it is difficult to control or change (Twyman et al., 2011). In the studies of Ben-Shakhar and Elaad (2002; 2003), it was shown that this method can be effective in criminal investigations. For instance, when one is confronted with critical items, like items that are related to a crime, it will bring out enhanced psychophysiological responses (heart rate, skin conductance etc.).The GKT is thus based on recognition of crime-related information that is stored in one's memory.

As has been indicated before, the technology of eye-tracking in combination with the GKT is being investigated. Multiple research has already been done in this field. For instance, in the research of Ryan, Hannula, and Cohen (2007), an eye-track study was conducted where participants were shown three-face displays where either all of the faces were unfamiliar to the participants or where one of the three faces was familiar. An essential finding in this study was the recognition effect, indicating that people have a longer fixation duration on known faces than on unknown faces. This suggests that a longer fixation duration is a cue for recognition (Schwedes & Wentura, 2012). In another study of Kovalev et al. (2016) it was shown that the count and duration of fixations, blinks, and saccades might act as reliable indicators in the detection of concealed information. Meaning that the combination of the GKT and the eye-track technology can increase the chance of discriminating between deceivers and truth-tellers by detecting who is holding crime-relevant information. Because of the contribution of the eye-track technology, in combination with the GKT, to separate liars from truth-tellers, the theory and methods behind eye-tracking will be further described.

Eye-tracking

Eye-tracking technology has gone through major developments the last decade, making it a valuable asset in not only in the field of marketing and product design, but also in psychology (Dickson, 2017; Selimis, 2015; Holmqvist, Nyström, Andersson, Dewhurst, Jarodzka, & van de Weijer, 2011). The technology enables one to gain insight in behaviour or in designing new user interfaces (Tobii, 2018). The sensor technology is also widely applicable, because it is possible to know exactly where someone's eyes are focusing on and the sequence in which people are shifting their eyes from location to location (Poole & Ball, 2006). This shifting from location to location is also known as a saccade and are the rapid-eye-movements between fixations, for example; word to word reading (iMotions, 2018; Holmqvist et al., 2011). They are the fastest movements that the body can produce and are often measured and reported during studies (Holmqvist et al., 2011).

Modern eye-tracking techniques can thus determine an accurate gaze direction of participants (Boraston & Blakemore, 2007). This accurate gaze direction is possible, because the technology can now record the position of the eye and movement in an environment that is based on optical tracking of corneal reflections to assess visual attention (iMotions, 2017.). The two most prominent metrics that are used in the eye-track literature are 'gaze points' and 'fixation points' (iMotions, 2018). The concept of gaze points is described as the basic unit of measure. One gaze point is equal to one raw sample that is captured by the eye-tracker. If the eye-tracker measures 60 times a second, then one gaze point represents a sixtieth of a second (16.67 ms). When several gaze points are close in time, a fixation is formed. A fixation duration is typically 100-300 ms (iMotions, 2018).

Guilty Knowledge Test in combination with eye-tracking

Various other studies have used eye-tracking in trying to detect deception as well. For instance, in the study of Derrick et al. (2011), it was examined whether it was possible to discover people who possessed guilty knowledge using the eye-tracker. The study developed a scenario where guilty participants constructed an improvised explosive device and where innocent participants did not. Later in the experiment, participants viewed an altered image of this device, where guilty participants should be aware that the image was modified in contrast to innocent participants. This resulted in guilty participants having a longer fixation duration on the altered part in comparison to the innocent participants. The results of the study showed a 100% accuracy rate in discriminating between guilty- and innocent participants (Derrick et al., 2011). Though, it should be mentioned that only 11 participants were part of this

experiment, which could have resulted in a low external validity. In another study of Peth et al. (2013), guilty- and innocent subjects were examined who were undergoing a standard GKT, while their eye-movements were recorded. A mock crime was developed where emotional arousal and the time between the mock crime and the GKT were being manipulated. The results of the study showed that there were longer fixations on known objects whose recognition was concealed by participants. Also, in 65% of the trials concealed knowledge was detected. The study provided further evidence that eye-movements are suitable for detecting concealed information.

Aside from the guilty- and innocent suspects, there is another important group that might also hold important/critical information. This group can be defined as the accomplice group. According to the dictionary, an accomplice is someone who works with or helps someone who is doing something wrong or illegal (learnersdictionary, 2018). For instance, when someone is hiding illegal products, like weapons and/or drugs in their house, other people, aside from the perpetrator, might have knowledge of the location of these items. For example, family that is living in that same house. These people could possess critical information. Though, not much has been written about this group. It is for this reason that the current study will include accomplices as well. Hopefully, this study can contribute in the knowledge about the eye-movements of accomplices in comparison to guilty- and innocent suspects.

The current study

The GKT in combination with eye-tracking can thus lead to an increase in accuracy when discriminating between guilty- and innocent suspects. Therefore, the current study will research whether people who possess guilty knowledge differ in their eye-movement patterns in comparison to people who do not possess guilty knowledge. Within the current study, two metrics will be measured: fixation count and total fixation duration. The first metric, AOI fixation count, where AOI stands for Area Of Interest, is able to measure the number of fixations within each AOI, meaning that it is possible to see how many fixations each participant had on the selected AOIs. The second metric that will be measured, is total fixation duration. This metric measures the total time that is spent on an AOI. In other words, the metric enables one to see where the participant's interest may lay and seems to be an excellent measure of visual attention (iMotions, 2018; Holmqvist et al., 2011).

In order to manipulate the guilty knowledge, a mock crime, revolving around a drug crime, has been developed and presented to the participants. Participants will be randomly assigned to one of the three conditions: guilty condition, accomplice condition, or the control

condition. In the guilty condition participants will store a bag of synthetic drugs themselves inside their garage. In the accomplice condition participants will be an accomplice in storing synthetic drugs in their garage. In the control condition participants will be told that they just cleaned out their garage. Participants in the first- and the second condition will have guilty knowledge and will be asked to lie during the experiment. In the control condition participants will have no guilty knowledge and will be asked to tell the truth.

Hypotheses fixation duration

According to the research of Peth et al. (2013), guilty people who are familiar with crime-related details will have a longer fixation duration on these details than innocent suspects. In the current study, participants in the guilty condition have stored drugs in a white flowerpot themselves, and possess knowledge about the exact location. Whereas participants in the accomplice condition will be aware of the fact that drugs are stored inside a white flowerpot, but they do not know the exact location of this flower pot. Also, the control condition has no guilty knowledge and does not possess any information regarding the crime. It is therefore expected that in the fixation duration hypothesis a), participants in the guilty condition will have a longer total fixation duration on the crime-related object in comparison to the accomplice condition and the control condition, since they have exact knowledge of the crime-related object.

Subsequently, participants in the accomplice condition have knowledge that the drugs are stored inside a white flower pot, but they do not know the exact location of the crime-related object. It is therefore expected that in the fixation duration hypothesis b), participants in the accomplice condition will have a longer fixation duration on the crime-related object than participants in the control condition.

Hypotheses fixation count

It seems that people who experience a stronger psychological response to crime-related details have an overall decrease in fixations (Peth, et al., 2013). Regarding the metric fixation count, participants in the accomplice condition are in the possession of guilty knowledge, but do not know the exact storing location of the drugs. This would make it more likely that these participants will look around more than guilty participants. It is therefore expected that in the fixation count hypothesis a), participants in the accomplice condition will have a higher fixation count in the picture of the garage than participants in the guilty condition. Subsequently, since participants in the control condition are not in the possession of guilty knowledge, it is likely that these participants will look around more. It is therefore expected that in the fixation count

hypothesis b), participants in the control condition will have a higher fixation count than participants in the accomplice condition and the guilty condition.

Explorative variables

In addition to measuring the eye-movement patterns, which can serve as an objective source in finding if there is a difference in gaze behaviour between people with- and without guilty knowledge, two psychological factors will be included in the study that might play a role in the experiment. These factors are anxiety and stress.

Anxiety. Since participants in the guilty- and accomplice condition might experience a higher cognitive load, because they are instructed to lie, it is possible that they have higher levels of anxiety than the control condition. On the other hand, because participants in the control condition are innocent, they might experience high anxiety levels as well. After all, these participants do not know why they are being asked to come to the police station. For this reason, we want to investigate if the manipulation of the guilty knowledge had an effect on participants anxiety level in the three different conditions.

Stress. Since participants in the guilty- and accomplice condition are asked to lie, they might experience a higher cognitive load which could result in a higher stress level. On the other hand, it is also plausible that participants in the control condition might experience a higher stress level, because they are innocent and do not know what is going on. We are curious to see whether there is a difference in the level of experience of stress after the manipulation of guilty knowledge between the three conditions.

Method

Participants

There were 71 participants who voluntarily participated in the experiment. The inclusion criteria to be able to participate in the study were that participants had to be 18 years or older, agree in participating in the experiment and in using their data, and be able to read English. Participants who failed to meet these criteria were not included in the study. Also, participants whose data was not sufficient to use in analyses (due to malfunction of recordings or participants not finishing the experiment etc.), were also excluded. After the selection, there were 63 participants left (23 women and 40 men). Their age ranged between 18 and 63 years, with a mean of 35 years (SD = 14.44). Most participants originated from the Netherlands (87.3%) and the most frequently completed level of education was MBO (42.9%). Furthermore, all participants had normal or corrected-to-normal vision (glasses or eye-contacts).

Design

The research design of this study was a between-subjects design which consisted out of two experimental groups and one control group with no pre-test. Participants were randomly assigned into one of the three conditions: guilty condition (N = 23), accomplice condition (N = 19), or the control condition (N = 21). Both the guilty- and accomplice condition possessed guilty knowledge, while the control condition did not possess guilty knowledge. The dependent variables in this study were total fixation duration on the crime related object (AOI 1) and fixation count on the picture of the garage as a whole (AOI 2). The dependent explorative variables were anxiety and stress.

Procedure and Apparatus

After getting ethical approval, participants were gathered through SONA and the researcher's social network. Participants were allowed to take part in the experiment after meeting the inclusion criteria, including their informed consent (Appendix A). The experiment was conducted in English for all participants. Participants were tested individually and were separated from others in a secluded room. Each session had a duration of approximately 15 minutes. During the experiment a wearable eye-tracker (TobiiPro glasses 2) was used. The eye-tracker works as follows; it consists of projectors, cameras, and algorithms. The projectors within the eye-tracker create a pattern of near-infrared light toward the centre of the eyes (pupils). This causes visible reflections in the cornea, which are the outermost optical element of the eye. The cameras then take high-frame-rate images of the user's eyes and the patterns. Subsequently, due to the image processing algorithms, it is possible to find specific details in the user's eyes and reflection patterns. Based on these details, mathematical algorithms calculate the eyes' position and gaze points on an image (iMotions, 2017). Aside from the eye-tracker, a Dell Venue tablet was also used.

During the session, one experimenter, who was also the researcher, was present. After signing the informed consent, participants had to put on the wearable eye-tracker. The eye-tracker had to be as tight as possible, while the participant still felt comfortable wearing them. After making a Wi-Fi connection between the eye-tracker and the tablet, the Tobii controller app on the tablet was started. The eye-tracker was placed and calibrated around one meter in front of the participant using the Dell Venue tablet. Subsequently, the button 'record' was pressed on the tablet. The eye behaviour of the participants could then be measured by the eye-tracker. The eye-tracker enabled the device to track both eyes at the same time. The device that was gathering the data was put on the table by the participants when they sat down so that the

device would not be turned off.

When informing the participants about the purpose of the study, they were told that it was about whether eye-tracking could be used in police investigations. Participants would be presented with familiar and/or unfamiliar environments. Using eye-track technology, it would be possible to measure eye-movements. Participants were then asked to start the survey tool. Depending on the condition in which the participants were randomly assigned in, the situations the participant read, in a first person perspective, would differ. This difference mainly took place at the beginning of the situations and a full overview of these situations can be viewed in Appendix B.

Guilty condition. In the guilty condition, participants read information regarding their situation. It became clear here that they were going to store drugs in their garage. Participants viewed a video where they were standing in front of their garage while looking around. Subsequently, it was then shown that the participants were storing a bag of drugs in a white flower pot that was standing on a shelf on the right in the garage.

Accomplice condition. In the accomplice condition, it became clear for the participants that a man was going to store drugs in their garage, with their consent, in exchange for 10.000 euro. After the man left, participants checked the garage. They were then presented with a video where they were standing in front of the garage while looking around.

Control condition. In the control condition, participants read a scenario that explained that they cleaned out their garage. A neighbour came by and the participant wanted to show the cleaned out garage, but decided to check the garage first before showing it. They were then presented with a video where they were standing in front of the garage while looking around.

Participants then had to imagine that a police officer visited their house and asked the participants to come to the police station to answer some questions. Notice here that participants in the guilty- and accomplice condition were instructed to lie during the interrogation and to deny any accusation that might lead the police to know that the participant is involved in illegal activities. While participants in the control condition were instructed to be honest during the interrogation. The police officer then explained to the participants that he was going to show some pictures and asked if they had any idea if the pictures had anything to do with a certain crime. Two photos were then shown to the participants. One picture is a control photo of a living room (figure 1) and the other picture is a photo of the crime-scene, the garage (figure 2).

Figure 1. Control photo in the experiment

Figure 2. Photo of the garage in the experiment

Participants were then asked to fill in a post questionnaire which contained questions about participants' sex, age, nationality, and educational level. In addition to this, participants had to fill in statements, derived from the Depression Anxiety Stress Scales (DASS) of the study of Lovibond and Lovibond (1995). From the DASS, the scales of 'anxiety' and 'stress' were used. Higher scores on each scale indicate a higher level of anxiety or stress (Parkitny & McAuley, 2010). A 5-point scale was used during the experiment, which ranged from entirely disagree to entirely agree. For the dependent variable 'anxiety' 10 statements such as: 'I had difficulty swallowing' and 'I experienced trembling (e.g. in the hands)' were used. In order to

measure the dependent variable ‘stress’ participants had to answer 10 statements such as: ‘I found it difficult to relax’ and ‘I felt that I was using a lot of nervous energy’. A complete overview of these statements can be viewed in Appendix C.

After participants finished the experiment, the examiner told the participants that the experiment was over and that the eye-tracker could be removed. Participants got a debriefing and the true motives behind the experiment were revealed. The examiner also reminded the participants not to talk to other participants outside of the room about the experiment.

Analysis

With a wearable Tobii eye-tracking device the data of the participants were gathered and later put into a data set. After that, the data was transferred to Tobii Pro Lab (x64) for further analyses. The attention filter was used here with a threshold of 100 degrees per second. In order to investigate the hypotheses, regarding the metrics total fixation duration and fixation count, certain Areas of Interests (AOI) were set on the picture of the garage. AOI’s are a tool that enables one to select regions of a displayed stimulus, in this case the picture, where the metrics of total fixation duration and fixation count can be calculated. With the use of the AOI’s it is possible to evaluate the performance of two or more areas in the same picture, and groups can be compared (iMotions, 2018). There are a total of two AOI’s in the picture of the garage (see figure 3). AOI 1 was assigned to the crime-related object; the white flower pot where the drugs were stored in. AOI 1 was chosen, because it will be examined whether participants in the guilty condition will have a longer total fixation duration on the flower pot than participants in the accomplice- and control condition. And whether participants in the accomplice condition would have a longer total fixation duration on the crime-related object in comparison to the control condition. AOI 2 has been assigned to the picture of the garage as a whole. Assigning the whole picture as AOI was is crucial, because it makes it possible to evaluate where participants are looking in the whole picture and to measure the two metrics in other areas.

AOI1 Crime-related object

AOI2 Picture of the garage

Figure 3. Photo of the garage with the corresponding Areas of Interests

During the analysis of the data in Tobii-software, it came to surface that an error during or after the calibration occurred when measuring the eye-movements of some of the participants. For instance, when it was expected that a participant looked at the play button of the YouTube video, and clicked on the button to play, their focus point on screen may have varied from the actual focus point (the play button). Meaning that the actual focus point was three centimetres underneath the expected focus point, the play button. According to Vadilloa, Street, Beesley, and Shanks (2015), even small calibration errors could have harmful effects on the interpretation of experimental data. If left undone, the results could have represented false focus points. Therefore, the choice was made to perform manual correction in the cases where these errors were expected to have occurred. Before the actual manual correction, there were three points chosen that would determine the length between the false focus point and the expected focus point. The first point was the 'next' button in order to proceed the experiment, the second point was the play button on the YouTube video, and the third focus point was another 'next' button. These points were chosen, because it is assumed that participants need to find and focus on these points in order to click on them. In the end, of the 63 participants, the manual correction has been executed on 33 participants. In the process of manual correction, the researcher was unaware in which condition the participant was placed in.

Furthermore, heatmaps have been created in order to visualize the data and to show the

general distribution of visual attention (iMotions, 2018). These heatmaps can be viewed in Appendix D. The red colour areas suggest a high number of gaze points, which can imply a high level of interest. Yellow and green colour areas show fewer gaze points, which may imply a low(er) level of interest. Whereas areas that do not show any colour at all are likely not to have been attended at all (iMotions, 2018). The data was then transferred from Tobii to Excel using the export option, and from there to SPSS v. 23 to analyse the data further.

Results

Fixation duration

A test for normality, the Shapiro-Wilk Test, has been executed on the metric of total fixation duration. An alpha level of .05 was used for all statistical tests. The test revealed that the data of total fixation duration was not normally distributed ($p < .05$). The assumptions to use an one-way ANOVA were thus not met. Therefore, for the fixation duration hypothesis a) and fixation duration hypothesis b), an alternative non-parametric test has been used; the Kruskal-Wallis H Test.

The fixation duration hypothesis a) expected that participants in the guilty condition would have a longer total fixation duration on the crime-related object (AOI 1) than participants in the accomplice condition and the control condition. Subsequently, the fixation duration hypothesis b) expected that participants in the accomplice condition would have a longer total fixation duration on the crime-related object than participants in the control condition. The Kruskal-Wallis H Test revealed that the difference of total fixation duration on the crime-related object, between the guilty condition, accomplice condition, and control condition, was not statistically significant. $\chi^2(2) = 3.99$, $p = .14$. The mean rank scores for the three conditions were: guilty condition: 34.72, accomplice condition: 35.26, and the control condition: 26.07. Thus, hypothesis 1 and 2 have not been confirmed.

Fixation count

A Shapiro-Wilk test has been executed on the metric of fixation count with an Alpha level of .05. The test revealed that there was a normal distribution regarding the metric of fixation count ($p = .26$). For this reason, an one-way ANOVA with a confidence interval of 95% has been used to analyse the data.

In the fixation count hypothesis a) it is expected that participants in the accomplice condition will have a higher fixation count in AOI 2 than participants in the guilty condition. Subsequently, in the fixation count hypothesis b) it is expected that participants in the control

condition will have a higher fixation count in AOI 2 than participants in the accomplice- and guilty condition. The ANOVA test showed that there was no significant difference between the groups, $F(2,60) = 0.62$, $p = .54$. This result suggests that there is no difference between the participants in the guilty, accomplice, and control condition regarding their fixation count. Meaning that hypothesis 3 and 4 have not been confirmed.

Explorative analyses

Additional analysis have been executed on the metrics of fixation count on the crime-related object: $\chi^2(2) = 4.39$ $p = .11$, visit count on the crime-related object: $\chi^2(2) = 3.87$, $p = .14$, and total visit duration on the crime-related object: $\chi^2(2) = 0.58$ $p = .75$. Again, no statistical differences have been found.

Regarding the explorative variables, we were interested to see whether the three conditions differed from each other in their anxiety and stress levels after the manipulation. Both variables showed not to be normally distributed ($p < .05$) and a Kruskal-Wallis H test was therefore used.

Anxiety. The Kruskal-Wallis H Test found no significant differences between the conditions regarding anxiety, $\chi^2(2) = 1.13$, $p = .57$. The mean rank, presented on a 5-point scale, of the guilty condition was 3.52, the mean rank of the accomplice condition was 2.99, and the mean rank of the control condition was 3.03.

Stress. The Kruskal-Wallis H Test found no significant differences between the conditions regarding stress, $\chi^2(2) = 0.41$, $p = .82$. The mean, presented on a 5-point scale, of the guilty condition was 3.29, the mean rank of the accomplice condition was 2.98, and the mean rank of the control condition was 3.31.

Discussion

The current study investigated whether people who possess guilty knowledge differ in their eye-movement patterns (i.e. total fixation duration and fixation count) in comparison to people who do not possess guilty knowledge. The results showed that people who possess guilty knowledge did not show different eye-movement patterns when watching the crime-related object or the entire scene compared to participants who did not possess guilty knowledge. Also, participants in the accomplice condition did not show different eye-movements compared to guilty- and innocent participants.

Aside from the metrics of total fixation duration and fixation count, two explorative psychological dependent variables (anxiety and stress) have been investigated as well. The

results show no differences in the experience of anxiety and stress for guilty, accomplice, and innocent participants. The overall levels of anxiety and stress, on a 5-point scale, were average. Guilty condition: anxiety (M = 3.52) stress (M = 3.29), accomplice condition: anxiety (M = 2.99) stress (M = 2.98), control condition: anxiety (M = 3.03) and stress (M = 3.31).

The results on the eye-movements are thus not in line with prior research of Kovalev et al. (2016), Peth et al. (2013), and Derrick et al. (2011), who showed that guilty people have a longer fixation duration on crime-related details, and that innocent people have a higher fixation count. There could be several reasons for the differences found in this research in comparison to previous research.

Firstly, one explanation might be that the study has a power issue. Due to small sample size, it is possible that existing differences in eye-movements may not have been detected. The first recommendation for future research, in order to get a more representative sample and significant results, would therefore be to increase the sample size.

Secondly, the manipulation of the guilty knowledge during the experiment might not have been strong enough. Participants were asked to sit in front of a laptop and were asked to imagine to experience the scenario's, videos, and being interrogated by a police officer. Due to the imaginary nature of this study, it is conceivable that participants may not have taken sufficient perspective of what they would experience when actually being in that situation. This explanation is in line with the anxiety and stress results which show no differences between the conditions. Thus, involvement might have played a role here. Previous studies, in which differences in eye-movement were obtained, involved the participant more during their experiment than the current study. For instance, in the study of Derrick et al. (2011), participants were instructed to construct an improvised explosive device whereas innocent subjects did not construct such a device. In the research of Peth et al. (2013), guilty participants were instructed to steal valuables in a room, while innocent suspects were instructed to an alternative task. Participants in these studies were thus more actively involved in the experiment which might have produced a higher arousal level, and the experiment might have felt more real to participants than the current experiment. A recommendation for follow-up research would therefore be to make the experiment more realistic for participants to make them feel more involved and to experience a higher arousal level. This could be done by doing an experiment where participants have to hide a bag of drugs in a garage box themselves or where a real man directly asks them if he could use their garage. Another possibility is the use of Virtual Reality (VR). According to the research of Cornet, den Besten and van Gelder (2019) the use of VR lets users experience situations in a virtual environment. One of the benefits of VR is that it is

possible to let participants experience situations that would, for example, be unethical to do in real-life. The technology offers possibilities for behavioral changes, transferring knowledge, training, and research. Still, even though VR offers lots of possibilities, the use of VR comes with downsides as well. According to the same research of Cornet et al. (2019), the most important issues with VR revolve around hardware, content, applying VR in practice, and ethical considerations.

Thirdly, another limitation of the study is that manual correction on eye-track data was necessary on 33 of the 63 cases, because of possible errors that occurred during or after the calibration. This error could have had several causes; environmental circumstances (e.g. sunlight), participants touching their eye-tracker after calibration, or calibration that has been done facing the other side of the laptop where participants performed their tasks during the experiment etc. It should be mentioned that, although the manual correction was executed while being unaware of which condition the participant was placed, the accuracy of this correction could be questionable. Still, the manual correction was executed with the use of three 'checkpoints' in order to get the most accurate focus point that was possible. It is therefore important for future research to remind participants not to touch their eye-tracker when the calibration has been completed.

A final, partly contrasting, explanation, which might be less likely if participants were lowly involved, is that participants were taking counter-measures strategies to try and deceive someone, because of the legal context of the experiment. This could have manifested itself in guilty participants trying to avoid the crime-related object, which might have influenced the total fixation duration and fixation count. This phenomena is also known as 'super normality' (Cima, Van Bergen, & Kremer, 2008). Possible differences in eye-movements for guilty participants, in contrast to the other two conditions, might have evened out by counter-measures taken by these participants. Questions that arise, when thinking about this, are whether there are differences between guilty- and accomplice conditions in regard to taking counter-measures. Since this study is, to our knowledge, the first study that included accomplices as well in this kind of study, it would have been interesting to have asked participants if they took counter-measures strategies during the experiment. And, if they did, how they executed these strategies. A recommendation would therefore be to include counter-measures in future research to investigate this further.

Another recommendation for future research would be to include the three remaining white flower pots as AOI's as well. During this study, we assigned the crime-related object, the white flower pot where the drugs were hidden in, as AOI 1 and the picture of the garage as AOI

2. It would have been interesting to see whether there were differences in eye-movements between the three conditions regarding the other white flower pots as well.

In sum, the study investigated whether people who possess guilty knowledge differ in their eye-movement patterns, regarding their total fixation duration and fixation count, in comparison to people who do not possess guilty knowledge. The current study showed that there are no differences in eye-movements between guilty people (perpetrators and accomplices) and innocent people. This outcome is not in line with previous research of Derrick et al. (2011), Schwedes and Wentura (2012), and Peth et al. (2013). More research is necessary to investigate whether eye-tracking can contribute in discriminating between guilty- and innocent suspects. The study also gives valuable insights in the importance of a strong manipulation, the involvement of participants and the sample size which should all be taken into account in future research.

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Appendices

Appendix A Informed consent

Dear participant,

Thank you for participating in this study. By signing this informed consent, you agree that you have been clearly informed about the nature and method of this research. The received data will be confidential and processed anonymously, meaning that your name will not be associated with any research findings. Also, the data will not be accessible for third parties. Your participation is completely voluntarily, meaning that you can withdraw at any time from this experiment, without any reason necessary. If further information is needed about this research, please feel free to make contact with the researcher; Renske Korenromp (r.a.m.korenromp@student.utwente.nl).

_____	_____	_____
Participant name	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

Appendix B The different situations for each condition

Guilty condition

Imagine the following: you are a resident of Enschede, and through an acquaintance of yours, you were able to rent a small farm in the region, for a relatively low rent. The farm is perfectly located, it is near the university, but you also have some privacy, because of the trees that are surrounding your home. Aside from the space, the farm also comes with a garage, which is stored with small stuff from your acquaintance. You're at home, doing some homework and watching some Netflix when your doorbell rings. When you open the door, there is a man standing in front of you. The man is no stranger of yours, he is a work partner of yours. Your work though is not a student's average side job. You are involved with the production of (synthetic) drugs. You know that it is not the right thing to do, but on the other hand, with the pay, which could be 10.000 euro for approximately three weeks of working, you can pay the rent, pay off your student loan, go on vacation, and you are still able to do nice things with friends. Your partner explains that he is afraid that the police might know the location of the synthetic drugs lab, and he asks you to hide some of the drugs inside your garage. Your first reaction is, of course, no, but after the man asks you again, you eventually agree to it. So you grab your keys, take the bag of drugs that the man gave to you, and walk over to the garage.

Accomplice condition

Imagine the following: you are a resident of Enschede, and through an acquaintance of yours, you were able to rent a small farm in the region, for a relatively low rent. The farm is perfectly located, it is near the university, but you also have some privacy, because of the trees that are surrounding your home. Aside from the space, the farm also comes with a garage, which is stored with small stuff from your acquaintance. You're at home, doing some homework and watching some Netflix when your doorbell rings. When you open the door, there is a man standing in front of you. He asks if you are the owner of the garage outside. When you confirm that the garage is yours, the man makes a somewhat odd proposal. He asks if he could use your garage for two weeks to store some 'products'. Your first reaction is, of course, no, you have a feeling that these 'products' are no legal 'products'. But then the man offers you 10.000 euro to use your garage for two weeks. You think about it again, you know that it is not the right thing to do, but on the other hand, with 10.000 euro, you can pay the rent, pay off your student loan, go on vacation, and you are still able to do nice things with friends. So even though you do not feel entirely comfortable about it, you agree to it. You give the garage key to the man so he can hide these 'products' somewhere in the garage.

Eventually, the man comes back and tells you that he hid it away somewhere. You ask where he hid it, and the man tells you that he hid it inside the white flower pot. When the man left, you became curious, so you grab your keys and walk over to the garage.

Control condition

Imagine the following: you are a resident of Enschede, and through an acquaintance of yours, you were able to rent a small farm in the region, for a relatively low rent. The farm is perfectly located, it is near the university, but you also have some privacy, because of the trees that are surrounding your home. Aside from the space, the farm also comes with a garage, which is stored with small stuff from your acquaintance. You're at home, doing some homework and watching some Netflix when your doorbell rings. When you open the door, there is a man standing in front of you. The man is no stranger to you, he is, in fact, your neighbour. You have known the man for quite some time, and you consider the man as a friend. Lately, you have been busy with cleaning out the garage, it was one of the deals you made with your acquaintance after all, in exchange for the relatively low rent. You are pleased with the result, and you wanted to show it to your neighbour as well. So the both of you agreed on today's date to show him the end result. But, before the both of you head over to the garage, you want to make sure that the garage is in the state in which you left it. So you tell your neighbour to wait for a bit, grab your keys, and walk over to the garage.

Appendix C DASS statements regarding the explorative variables Anxiety and Stress

Anxiety statements

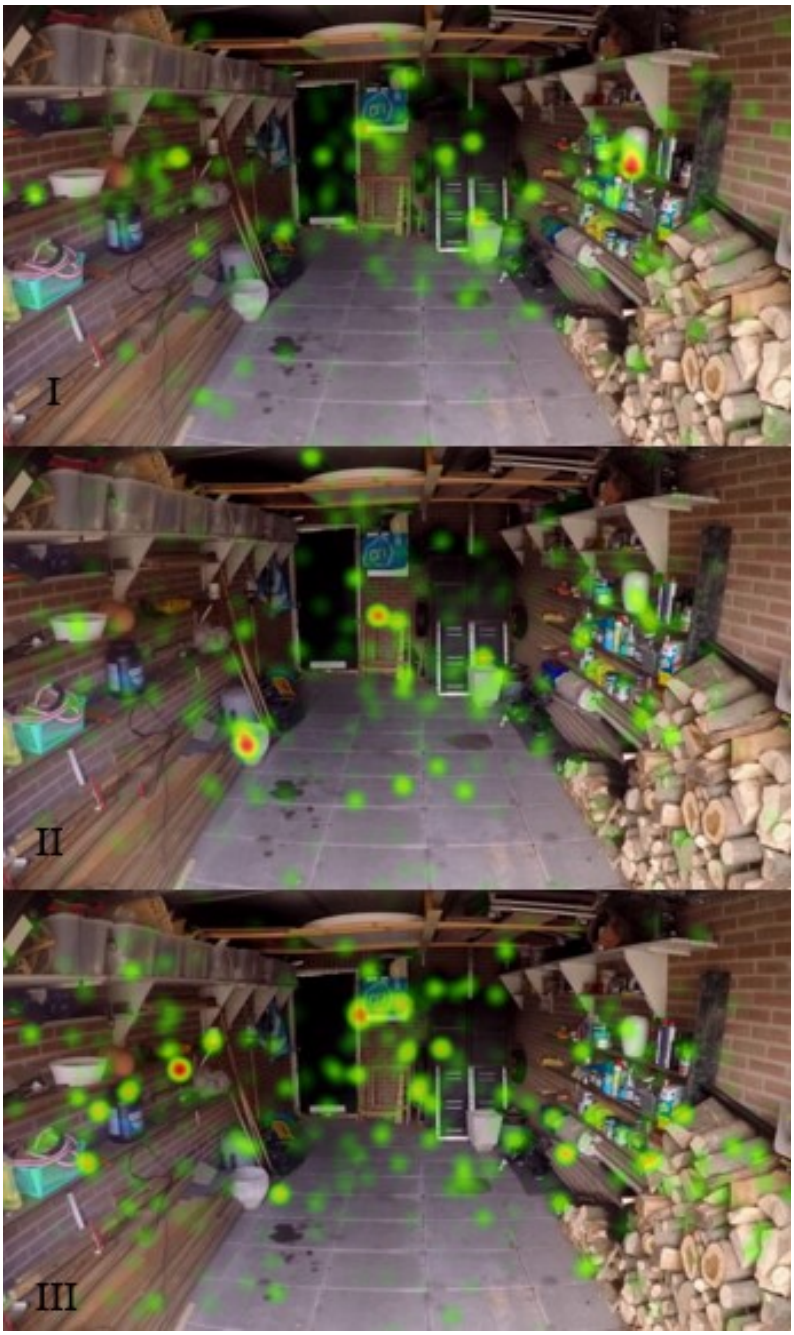
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I was aware of the action of my heart in the absence of physical exertion (e.g, sense of heart rate increase, heart missing a beat)					
I was aware of dryness of my mouth					
I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)					
I had difficulty in swallowing					
I had a feeling of shakiness (e.g. legs going to give way)					
I experienced trembling (e.g. in the hands)					
I found myself in situations which made me so anxious I was most relieved when they ended					
I felt I was close to panic					
I felt terrified					
I had a feeling of faintness					

Stress statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I found it hard to calm down after something upset me					
I found it difficult to relax					
I felt that I was using a lot of nervous energy					
I was in a state of nervous tension					
I found myself getting upset rather easily					
I found myself getting upset by quite trivial things					
I found myself getting agitated					
I tended to over-react to situations					
I found that I was very irritable					
I felt that I was rather touchy					

Appendix D Heatmaps regarding the absolute duration and absolute count

Heatmap 1 Absolute duration of fixations between the conditions (I) Guilty (II) Accomplice (III) Control



Heatmap 2 Absolute count of fixations between the conditions (I) Guilty (II) Accomplice (III) Control