

# Virtual Reality: a Promising Tool for Criminal Investigation?

*A research into the application of Virtual Reality in Crime Scene Investigation*



Juliette Dominicus (5644917)  
Supervision: Rianne van Lambalgen  
Second Reader: Thijs Jeursen  
Utrecht University, 2019  
Number of words: 8016 (7.5 ECTS)  
June 27, 2019

## Abstract

Criminal investigation is important for making reliable reconstructions of crimes. However, the information collected in criminal investigation might be subject to cognitive flaws. Flaws in criminal investigation are contextual bias, confirmation bias and tunnel vision, limited time and capacity and selective retelling. The criminal investigation can be seen as a distributed cognition that consists of multiple stages. In each stage information derived from decision-making is transferred to the next stage. For each stage, multiple cognitive fallacies reduce the reliability of the criminal investigation. Virtual Reality (VR) might be a useful tool to reduce these cognitive errors. This research investigates what impact VR has on cognitive factors in criminal investigation. Results show that VR might be a powerful tool as it enhances learning, reduces cognitive load, creates virtual context reinstatement and improves evidence collection. However, there is still a lot unknown when it comes to the limitations of VR.

**Keywords:** *Virtual Reality, Crime Scene Investigation, Human Cognition, Distributed Cognition*

## **Preface**

As a Liberal Arts and Sciences<sup>1</sup> student, I have always had a hard time picking a single topic to investigate. For this thesis, I wanted to pick a topic that combines all my interests: neuropsychology, criminology, new media and a little bit of philosophy. I somehow managed to find a topic that covers all of these disciplines, which I will explain. This research is conducted for my main specialization within Liberal Arts and Sciences: cognitive neurobiological psychology. However, besides psychology, criminology and criminal behavior have always caught my attention. I have always questioned why people commit crimes and especially how reliable the current methods used in criminal investigation actually are. I followed the minor criminology and found out that a lot of the behavior studied in criminology is derived from psychological theories. Apart from psychology and criminology, I'm interested in new media and innovation. Right now, I'm working as an intern at the Netherlands Film Festival. This is where my interest in virtual reality<sup>2</sup> started. I found out that virtual reality is used for many purposes: for art, for game-design and for neuropsychology. During my internship I met an artist who created his own world in virtual reality: a world in which he could enter spaces that he created himself, could listen to the music he likes, and in which he could escape reality for a while. I started researching themes at the intersection of VR, cognition and criminology and discovered that VR is currently being used for crime scene reconstructions. Then I immediately knew that I wanted this as the topic for my thesis. By writing this thesis, I learned that the application of VR within police investigation is still in its infancy, making it a very interesting theme to investigate. I would like to thank everybody that contributed to this thesis and helped or inspired me to write it. Especially I want to thank my supervisors, Rianne van Lambalgen and Thijs Jeursen, who guided through the process and Liza and Ronald, who gave me permission to interview them.

---

<sup>1</sup> Liberal arts and Sciences is a study that focuses on interdisciplinarity, therefore making it possible for students to follow courses from multiple disciplines. Source: <https://www.uu.nl/bachelors/liberal-arts-and-sciences>

<sup>2</sup> Virtual reality is a highly interactive medium in which users can enter a virtual environment (Ma, 2010).

## **Table of contents**

<b>Abstract . . . . .</b>	<b>2</b>
<b>1. Introduction . . . . .</b>	<b>5</b>
<b>2. Cognition &amp; Crime Scene Investigation . . . . .</b>	<b>8</b>
2.1 Cognition and Cognitive Biases. . . . .	8
2.2 Crime Scene Investigation as a Distributed Cognition . . . . .	8
2.3 Cognitive Fallacies within Crime Scene Investigation . . . . .	10
<b>3. Cognition &amp; Virtual Reality . . . . .</b>	<b>14</b>
3.1 What is Virtual Reality? . . . . .	14
2.2 The Influence of Virtual Reality on Cognition. . . . .	16
<b>4. Application: Limitations and Considerations. . . . .</b>	<b>22</b>
4.1 Practical and Ethical Considerations: The Future of VR . . . . .	22
4.2 Limitations and Further Research . . . . .	23
<b>5. Conclusion and Discussion . . . . .</b>	<b>25</b>
<b>7. Literature. . . . .</b>	<b>27</b>
<b>8. Appendix . . . . .</b>	<b>30</b>

## **1. Introduction**

Criminal investigation is essential for a reliable reconstruction of crimes (Dutelle, 2014). The investigation of crimes focuses on reconstructing all the actions and events surrounding the committed crime and the crime scene (Chisum, 2011). Crimes can be reconstructed using several sources, such as eyewitness testimonies or the reconstruction of a crime scene made by the police (Chisum, 2011). It is important that these reconstructions are reliable and representative, since the conclusions of these reconstructions form the basis for further criminal sanctions in criminal proceedings (Dutelle, 2014). However, this reconstruction is often subject to flaws due to limitations of human cognition (Ditrich, 2015). With the advent of technological developments there is room for innovation within criminal investigation. Virtual Reality (VR) is an example of a very recent technological tool used by the police and could be a possible new outcome to improve the reliability of crime scene investigations (Siebert, 2018). By using VR, these investigations might be less sensitive to cognitive flaws and provide the police with a more representative, interactive view on the incident (Siebert, 2018). Since the past few years, VR has already been applied in several fields of criminal investigation. For example the usage of 3-dimensional (3D) reconstruction of evidence in courtrooms, providing judges with evidence as if being there (Schofield, 2007). These 3D reconstructions increase comprehension, efficiency and attention by making the evidence more interactive (Schofield, 2007). Another research done by Timmer (2016) shows how VR can be applied in eyewitness testimonies. His research shows that virtual context reinstatement has a positive effect on the quality and reliability of eyewitness testimonies (Timmer, 2016). However, these outcomes have not been explored extensively. The aim of this paper is to answer the following question: *What impact does VR have on cognitive factors in criminal investigation?*

### **Relevance to Cognitive Neuroscience**

The research done by Timmer is very recent and other research concerning the application of VR within criminal investigation is scarce. Cognitive flaws have been studied extensively within cognitive psychology, but also play an important role in criminal investigation (Ditrich, 2015). For example, people tend to interpret new information in a way that is consistent with their beliefs. This tendency is called the confirmation bias (Burke, 2005). Within the field of criminology, biases like the confirmation bias are important to study, as they might lead to

distorted information and judicial errors (Ditrich, 2015). Some research has been done regarding human memory flaws focusing on eyewitness testimonies (Timmer, 2016). However, cognitive fallacies that occur in crime scene reconstruction have not been investigated extensively. By considering crime scene investigation as a process of distributed cognition, more insight is created concerning cognitive fallacies within criminal investigation. A distributed cognition is a system in which activities are carried out by more than one agent (Baber, 2006). By understanding cognitive fallacies in combination with how VR might influence these fallacies, this paper aims to explore the possibilities of VR as a tool for criminal investigation from a psychological perspective. It focuses on a very recent application of VR: the use of VR for police crime scene reconstruction. By combining psychological theory with criminological practice, this paper attempts to gain more insight concerning the contribution of VR for criminal investigation. Such a contribution can be used for further applications in police context, taking into account all the theories, possibilities and shortcomings.

## **Structure and Research Questions**

The main question that will be answered in this paper is: What impact does VR have on cognitive factors in criminal investigation? In order to answer this question, the research is divided into three sections. The following sub-questions will be addressed:

- 1) Which cognitive fallacies occur in criminal investigation?
- 2) What influence does virtual reality have on cognition?
- 3) What are limitations and considerations when applying VR?

The first section investigates how cognition is involved in criminal investigation. It questions which fallacies occur in this criminal investigation by looking at the investigation process as a distributed cognition. Fallacies are described for each stage of the criminal investigation. The second section questions what influence VR has on cognition, focusing on the cognitive flaws described in the first part. It examines the effects VR has on enhancing cognition, and how these effects can reduce the fallacies. The third part explores the practical and ethical considerations that should be taken into account when applying VR in criminal investigation. It focuses on what is important in criminological investigation and how VR should be used. It includes two expert-interviews to give more insights regarding the considerations that come with the application of VR. The experts will be introduced in the methods section. The considerations and limitations section takes a further look into practical considerations and limitations of VR in

criminal investigations. It includes shortcomings VR might have and recommendations for future research. In the conclusion the parts will be integrated. It focuses on all the limitations, options and possibilities for current and future research on VR from a psychological and criminological perspective.

## **Methods**

To answer the research question, literature analysis was conducted using search engines Google Scholar and Scopus. Search terms for the analysis were: cognition, distributed cognition, criminal investigation, crime scene, crime scene reconstruction and virtual reality. Reviewed literature consisted of experimental research, police and judicial rapports, psychological papers, cognitive theories and books. However, since the application and usage of VR in criminal investigation is very recent, there was little to be found. Therefore, two expert interviews were added to this research. The first interview was held with neuroscientist Liza, who works as a researcher in juridical context. This interview was used to gain more insight in the role of cognition in juridical context, together with ethical and practical considerations. The second expert interview was conducted with chief of digital simulations of the Dutch police academy, Ronald. His expertise was used to gain more insight into how VR is currently used, future research and practical considerations from a police officer's perspective. A more detailed description of both interviews can be found in the attachments (Appendix, 1). For this paper, the experts are referred to by their first names.

For both interviews a semi-structural topic list was created based on the research questions (Appendix, 2). The created topics were: VR in general, application, personal experience, (cognitive) problems, cognition and VR, ethical issues and the future of VR. Specifications of the list are found in the appendix (2). The interviews were analyzed in two stages that are important for the analysis of qualitative data (Decorte, Zaitch, 2016). The first stage consisted of transcription and data reduction. Transcripts, summaries and memos from the two interviews were created and collected. Codes were then assigned to paragraphs in the interviews that referred to the topics of the topic-list (Appendix, 2). In the second phase, the codes were compared and used in chapter three of this paper.

## **2. Cognition & Criminal investigation**

In order to create a more comprehensive understanding concerning the cognitive fallacies that occur in criminal investigation, this section explores the psychological background of cognitive biases, how they occur in the crime scene and which fallacies specifically must be taken into account.

### **2.1 Cognition and Cognitive Biases**

‘Errare humanum est’ is an ancient expression to explain the limitations of human cognition (Sagana, 2003). These limitations, or *cognitive biases* can be described as the tendency to use mental shortcuts in situations of uncertainty (Sagana, 2003). It is important to note that this paper focuses on cognitive biases that occur without conscious awareness and are therefore mostly unconscious. Cognitive biases are not always problematic, as they provide the human mind with fast information about the environment and people (Bitzer et al., 2016). However, these biases might result in wrong decision-making (Baddeley, 1997). Concerning criminal investigation, often there is time pressure to solve a crime and uncertainty concerning what happened. Therefore, crime investigators are very susceptible to cognitive biases (Sagana, 2003). In order to understand which flaws might occur, each stage of the criminal investigation must be explored. As for each stage different biases may occur, the different types of biases will be discussed more in-depth in the following section.

### **2.2 Crime Scene Investigation as a distributed cognition**

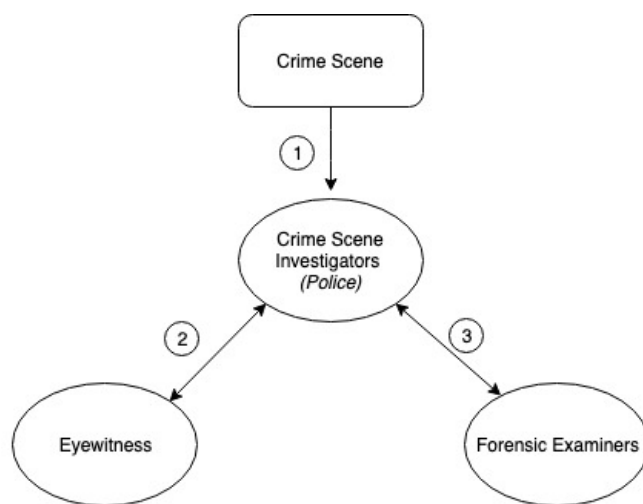
When looking at cognitive biases in criminal investigation, there is a particular focus on errors that occur in crime scene investigations (Sagana, 2003). However, the criminal investigation also involves an exchange of information with eyewitnesses, forensic examiners and judges (Baber, 2006). All of these actors operate as a whole. Therefore, according to Baber, the criminal investigation process can be seen as a distributed cognition (2006). In distributed cognition systems, cognitive activities are performed by more than one agent. Errors might not only occur in the process of crime scene reconstruction, but for example also in the exchange of information between the investigators and the eyewitness (Bitzer et al., 2016). Besides, they might occur in the stage between the investigators and the forensic examiners (Bitzer et al., 2016). Forensic evidence is not simply found; it is socially constructed (Julian et al., 2012). This social construction consists of all the different beliefs and expertise of each stage. Baber (2006)



points out that criminal investigations can be seen as a chain of events. For this research, a more simplistic version of this chain is described as follows: First, a crime is committed and reported. Second, the scene is investigated and evidence is retrieved. Third, the offender is caught or identified and charged. Fourth, all the information is processed and examined by the police including eyewitness testimonies, forensic reports and crime scene notes. Fifth, this information is further send to the Crown Prosecution Service to make a decision: to prosecute or not (Baber, 2006). In this thesis the focus will be on the first four stages, as these are the stages in which police investigators obtain a dominant role in the decision making process. After the first four stages, the police file is made up and send to the judges. However, as the judges operate independently, they are not discussed in this thesis.

In each stage of the investigative chain, information must be collected and disseminated to the next stage (Bitzer et al., 2016). For crime scene investigation, evidence is collected, analyzed and interpreted by different groups that are each specialized in specific tasks (Julian et al., 2012). If the reliability of these tasks is questioned, the evidence is declared invalid. In order to look at cognition within a crime scene investigation, the whole interaction must be observed (Bitzer et al., 2016). By pointing out which cognitive flaws occur in which stage, more insight is gained in what should be improved in terms of cognition.

The following section discusses each stage of the criminal investigation by pointing out which cognitive fallacies might occur. To illustrate this, the following figure is created (figure 1). In this figure the information processes are outlined in which cognitive biases may occur. Each stage will be discussed in the next section.



*Figure 1: information exchange within criminal investigation*

## **2.3 Cognitive fallacies within Crime Scene Investigation**

### ***Stage 1. Police Investigators***

The first stage of the chain comprises the crime scene reconstruction made by the police (Baber, 2006). It is the most important phase, as it forms the basis of the next steps in the process of criminal investigation (Bitzer et al., 2016). Therefore, it is important that information processed within this phase is not subject to cognitive flaws. If the investigators that inspect the crime scene start with a wrongful conviction, this idea is transferred to the next stages of the chain and this might result in judicial errors (Ask et al., 2017). Because of that, the main focus of the criminal investigation as a distributed cognition remains on cognitive flaws that might occur in stage 1: criminal investigators.

Research shows that the contextual bias of the crime scene, tunnel vision and the confirmation bias together with limited time and cognition capacity occurring in the investigator play an important role in this first stage (Ask et al., 2017). It seems that all of these limitations and flaws result in wrong collection of a limited amount of evidence, which results in a certain 'biased' belief of a suspect's guilt (Burke, 2005) In order to understand these limitations, each flaw is discussed below.

#### ***Contextual bias***

One of the cognitive biases that police investigators are especially vulnerable to is the contextual bias (Dror, 2015). Contextual biases occur as the expectations and desires that people use in order to approach an observation influence what is observed (Sagana, 2003). Compared to working in a forensic lab, the contextual exposure at the crime scene is very complex. Dror (2015) is one of the first to question the reliability of the human element, called the 'cognitive contamination' in crime scene investigators (Dror, 2015). The crime scene investigator makes a large part of the decisions in the investigation process. The initial identification of a crime scene, concerning the search for evidence in order to correctly reconstruct a crime, is executed by the crime scene investigator (Bitzer et al., 2016). Flaws in this initial identification can undermine further forensic investigation by not focusing on the right factors within the process. If the investigator has a strong belief on a suspect's guilt because of one piece of evidence, ambiguous pieces of evidence are interpreted as more valuable as well (Charman et al., 2017). If important evidence is not collected at the crime scene, it might get lost or might result in a wrong conviction (Bitzer et al., 2016).

Another main issue for collecting evidence at the crime scene, in contrast to the forensic laboratory, is that evidence cannot be re-examined and re-analyzed, as the evidence is not consumed for testing (Burke, 2005). The criminal investigators decision not to collect a certain piece of evidence cannot be revised. By doing so, uncollected evidence will get lost and the crime scene is no longer preserved (Burke, 2005). In this way, the contextual bias influences *what* is observed at the crime scene (evidence), resulting evidence-loss.

### *Confirmation bias and tunnel vision*

Another cognitive flaw that occurs within investigators is the confirmation bias (Ditrich, 2015). The confirmation bias is one of the tendencies of human cognition, suggesting that people tend to interpret information in ways that are in line with their existing beliefs (Ask et al., 2017). Ditrich (2015) points out that the confirmation bias is common to nearly everyone. However, in a forensic setting, it is extremely important to be self-aware on this bias as it might have consequences for the suspect (Sagana, 2003). To do so, officers must always critically reflect on the hypothesis and not expect them to be true already. This bias occurs at the crime scene as attention and perception are used when making a decision (Burke, 2005). As the confirmation bias gives the investigator a strong focus on a certain belief, evidence is often either overlooked or ignored and eventually gets lost (Ditrich, 2015). One of the main forms of official misconduct made by investigators is hiding exculpatory evidence from the defendant and the court (Ditrich, 2015). As these flaws might be due to cognitive flaws, it is important that procedural measures are created to avoid it (Ditrich, 2015). Due to the confirmation bias, investigators search for consistent information resulting in limited alternative options of what happened in a crime scene.

Tunnel vision is the product of the confirmation bias (Keith, 2006). When making sense of the information that we process, we use mental sets, or heuristics, in order to keep up with the information overload. These heuristics play an important role in decision making as they guide us through uncertainty and information overload (Rossmo, 2008). However, heuristics tend to ignore relevant information. Tunnel vision is an example of one of these heuristics (Burke, 2005). In a forensic setup, tunnel vision involves 1) the identification of a primary suspect, 2) collecting evidence about this suspect and 3) ignoring information that excludes the suspect's guilt (Rossmo, 2008). An example of a case in which tunnel vision resulted in wrongful conviction, is the case of the Schiedammer park murder (Bronkhorst, 2014). In this case Kees B. was wrongfully convicted of murder. This conviction was solely based on his confessional statement, which he had withdrawn later on. There was not much more evidence that proved his

guilt: however, there was evidence that questioned his suspicion (Bronkhorst, 2014). Later on, it turned out he was not the perpetrator: the case was based on tunnel vision (Bronkhorst, 2014).

### *Limited time and capacity*

Apart from these biases, there are other factors that influence police decision-making. These factors are limited time and limited capacity (Ask et al., 2017). Police officers have a limited cognitive capacity like every human being, resulting in impaired information processing and stress (Alison et al., 2013). When processing new information, processes of encoding, storing and recalling information are involved (Rossmo, 2008). Attention is needed to collect new pieces of information (Keith, 2006). However, when attention is disrupted, information cannot be stored effectively. Research shows that the average person can only hold up to seven pieces of information in their short-term memory (Rossmo, 2008). As police officers need to store, integrate and weigh the importance of information, these regular capacity limitations make up an important part of flaws in the first stage (Ask et al., 2017). Second, there is the limitation of time (Alison et al., 2013). As crimes need to be solved as quickly as possible, police investigators are under pressure. A consequence of high time pressure is an increased cognitive workload and stress (Alison et al., 2013). As police investigators have to interview eyewitnesses, report to the media, organize the investigation and reconstruct the scene, there is not enough time to collect all the relevant information properly (Rossmo, 2008). Due to this time pressure, mistakes are often made concerning the evidence that is collected (Rossmo, 2008).

## ***Stage 2. Police Investigators ↔ Eyewitness***

### *Confirmation bias and tunnel vision*

The next stage in the distribution is that of information that goes between the eyewitness and the police officers. It is important to note that if information is collected the wrong way in stage 1, flaws will also occur in stage 2. One of the cognitive fallacies in this stage occurs when the police investigators provide information to witnesses. After visiting the crime scene and hearing initial testimonies, officers often already have strong beliefs concerning the commission. As described in stage one, investigators tend to look for evidence that is consistent with the working hypothesis and ignore evidence that is inconsistent with their belief (Rossmo, 2008). Not only does this apply to physical evidence collected at the crime scene, but also to the eyewitness testimonies in stage 2. Any information that the eyewitness gives to the investigator, that is consistent with his believe, is more likely to be taken as the truth (Sagana, 2003). Studies show

that when people are assigned certain characteristics, participants will describe these people with these personality traits (Rossmo, 2008). It does not matter if these people really have the characteristics or not. By doing so, investigators might develop a strong belief about a suspect's guilt, resulting in tunnel vision (Sagana, 2003). The information the police investigators give to the eyewitness might rely on tunnel vision, and influence the witness. It is known that if police officers tell an eyewitness a suspect's guilt is proven, the eyewitness will be more likely to confirm with this information whether it is true or not (Burke, 2005). Again, this fault is already proven in the Schiedammer park murder described in stage one (Bronkhorst, 2014). This shows the importance of the avoidance of tunnel vision in stage one, as it might continue in stage two.

### *Selective retelling*

Another cognitive flaw might occur when the witnesses provides the police with distorted information (Timmer, 2016). An important part of the eyewitness testimony relies on memory recall. During this process, the underlying memory recall influences the memory report (Sagana, 2003). The way in which people recall events is partly influenced by the beliefs of the narrator and the social distance between the narrator and the audience (Burke, 2005). This phenomenon is called selective retelling (Sagana, 2003). Research done by Tversky and Marsh (2000) shows that participants tend to come up with more details if conviction is needed compared to when conviction is not needed. In the criminal investigation these results are important as it shows the urge of eyewitnesses to come up with conviction of a suspect, even if the suspects are not guilty (Sagana, 2003).

## ***Stage 3. Police Investigators ↔ Forensic Examiners***

### *Confirmation bias and tunnel vision*

In the third stage, the police officers are in contact with forensic examiners. Police investigators are under high pressure (Rossmo, 2008). In hierarchical organizations like the police, this pressure comes from many factors: demanding supervisor, media pressure and social-political influences (Nakhaeizadeh, 2015). The testing of DNA evidence plays an important role in the third stage (Sagana, 2003). Where DNA evidence might provide the police with clear evidence, it can also end in wrong convictions. DNA profiles are often incomplete, which makes it difficult to interpret these profiles. If the analyst already presumes that a defendant is guilty, he might be more likely to fit his profile with the incomplete profile (Nakhaeizadeh, 2015). By doing so, the

analyst overlooks other ways in which the DNA could have played a role in the case (Ditrich, 2015). An example of this cognitive flaw is that of the 1998's case, in which Josiah Sutton was wrongfully convicted for rape. Both eyewitness testimonies and DNA tests were involved in this wrong conviction (Ditrich, 2015). The DNA analyst in this case was aware that the eyewitness identified Josiah as the offender. The analyst was inclined to look for evidence consistent with the working hypothesis of Josiah's guilt, and ignored other possible theories and evidence (Nakhaeizadeh, 2015). It shows that even at this stage of the criminal investigation, the confirmation bias plays an important role (Sagana, 2003). As seen in stage one, this confirmation bias might lead to tunnel vision and therefore a biased interpretation of evidence or DNA (Ditrich, 2015). Again, it shows that the previous stages in the chain affect the later stages in a way that can result in wrong convictions.

### **3. Cognition & Virtual Reality**

Now that most relevant cognitive flaws are outlined, it is important to investigate if and how VR influences cognition. First a definition of VR is given, together with specific (dis)-advantages VR has on cognition. Secondly, the criminological relevant effects VR has on cognition are explored.

#### **3.1 What is Virtual Reality?**

In order to look at the application of VR in practice, a clear definition of VR is required. According to Hoffmann et al. (1997), VR is a 'fundamentally different mode of communication between computer and person'. It can be seen as a medium where interaction takes place between human and a computer simulation and in which a computer generated virtual environment can be entered in a three dimensional way (Hoffmann et al., 1997). VR can be distinguished from any other medium as it lets users experience 'real time' changes, resulting in an experience of high interactivity and reality in the virtual world (Nakhaeizadeh, 2015). Figure 2 shows the different techniques for forensic visualization as proposed by MA (2010). As you can see in the figure, VR distinguishes itself in its high level of interactivity. According to Ma, the use of 3-dimensional or Virtual Reality techniques is starting to replace traditional mediums within crime scene investigation (2010). VR can be seen as part of all computer-generated animations, instead of traditional animations such as photo's or textual evidence. Ma distinguishes four ways of computer-generated simulations within criminal investigation: virtual reality (VR), augmented reality (AR), CG 3D animation and a combination of real and synthetic imagery

(2010). AR can be seen as a combination of both VR and content of the real world. CG animation consists of the superimposition of 3-Dimensional objects over humans or real time objects (Ma, 2010).

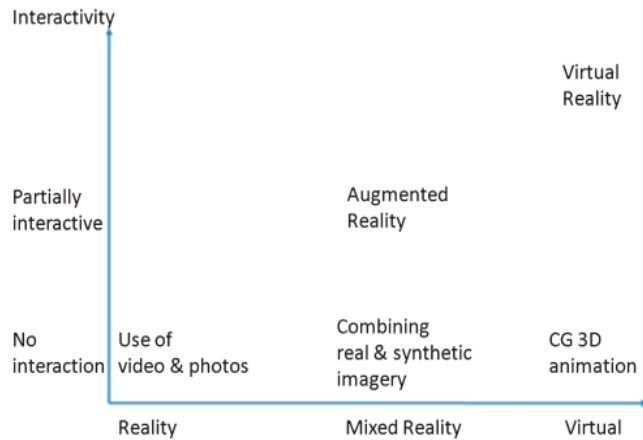


FIG. 1—Forensic visualization techniques.

Figure 2: Forensic Visualization Techniques (Ma, 2010)

VR is a tool that has been used for scientific research since according to the early 1990's, and since then it has become a promising tool as it enhances realism and reduces costs (Ma, 2010). For criminal investigation, VR is especially useful because of the virtual environments (VE) it creates (Hoffmann et al., 1997). VR provides a high representative construction of the crime scene by using a VE. Motion trackers are often used to track a user's movement and adjust the VE to the virtual world (Ma, 2010). As VR has the power to transport the user to a new environment, it might be a powerful tool (Cornet et al., 2019). In these virtual environments, users can move around in an interactive manner. The movements of the user are tracked and feedback is given to the VE to adjust to the user's movements (Van Gelder, 2014). VR differentiates itself from more traditional media as it generates such a high rate of interactivity. VR is distinctive from other traditional media in two aspects: the interactivity and immersion (Cornet et al., 2019). Unlike traditional media, the movements and actions of the user influence the experience of the medium (Van Gelder, 2014), making it highly interactive. The amount of immersion can be explained by the rate of realism experience within a VE (Hoffmann et al.,

1997). The more the inputs from the ‘normal’ sensory world are blocked, the higher is the illusion of full involvement for the user (van Gelder, 2014).

### **3.2 The influence of VR on cognition**

With the ability of creating new worlds with virtual environments, VR might be a promising tool to reduce cognitive flaws. As any environment, situation or perspective can be created, VR can be applied for many purposes (Howard et al., 2000). However, it must be noted that VR also has its limitations. Research shows that VR might have negative effects as well (Makransky, 2017). Negative effects and the limitations of VR are discussed in more detail in chapter three.

This section focuses on the possible influences VR might have on cognitive fallacies in criminal investigation. The cognitive fallacies discussed in the previous section were: contextual bias, confirmation bias and tunnel vision, limited time and capacity and selective retelling. VR is able to reduce these fallacies in several ways. For a clear overview of how VR could reduce these flaws, the results are put together in image 3 below [a higher resolution version of the image is added to the appendix– see appendix 3]. The results in this image are based on the information that has been compiled from the interviews and literature. The image shows all three discussed stages, together with the cognitive fallacies that were discussed in section two. On the right, the possible VR influences are depicted in boxes for each fallacy. Each fallacy in combination with the VR influences will be discussed. Some of the fallacies occur in multiple stages; therefore the same VR influences might be effective. However, how VR is applied to reduce the fallacies differs per stage. These differences are discussed as well. It must be noted that only few research has combined cognitive fallacies in criminal investigation with solutions of VR. Therefore, the following section also includes information from the conducted expert-interviews.



Stage	Cognitive Fallacies	VR Influences	
1. Police Investigator	<ul style="list-style-type: none"> <li>Contextual bias</li> <li>Confirmation bias and tunnel vision</li> <li>Limited time and capacity</li> </ul>	<div>Evidence collection + multiple perspectives</div> <div>Evidence collection + multiple perspectives</div> <div>Learning + reduced cognitive load</div>	<div>Education</div> <div>Opposing arguments + devil's advocacy</div> <div>Multiple perspectives</div>
2. Police Investigator ↔ Eyewitness	<ul style="list-style-type: none"> <li>Confirmation bias and tunnel vision</li> <li>Selective retelling</li> </ul>	<div>Evidence collection + multiple perspectives</div> <div>Virtual context reinstatement</div>	<div>Opposing arguments + devil's advocacy</div>
3. Police Investigator ↔ Forensic Examiners	<ul style="list-style-type: none"> <li>Confirmation bias and tunnel vision</li> </ul>	<div>Evidence collection + multiple perspectives</div>	<div>Opposing arguments + devil's advocacy</div>

*Figure 3: VR influences on cognitive fallacies*

## **Contextual Bias**

### *1. Evidence collection and multiple perspectives*

One of the main problems the contextual bias leads to is that of evidence loss (Rossmo, 2008). The contextual bias might lead to a certain focus on evidence consistent with the investigator's belief (Gibson et al., 2000). By making a virtual reconstruction of a crime scene, this problem might be reduced (Burke, 2005). VR has the ability to collect evidence in a highly complex, technical and spatial manner (Nakhaeizadeh, 2015). Whereas normal scene visits are short and evidence gets lost, VR reconstructions provide a 'frozen' version, which allows repeated research (Howard et al., 2000). Besides, many viewpoints can be taken to experience the crime when using VR: from the eyewitness view, from the victim's view or for example from the criminal's point of view (Ma, 2010). In this way, the investigator can observe the crime scene

from multiple perspectives. Another way of creating multiple perspectives, is pointed out by Ronald during the expert-interview:

“For making a crime reconstruction, police officers enter the crime scene and make a virtual scan. Compared to the traditional method, in which pictures and videos are made to reconstruct the scene, the VR method of crime reconstruction makes it able to walk through the scene multiple times. This also gives the opportunity for other police officers that were not present at the scene to interact with the crime scene (Ronald, appendix 1).”

In this part of the interview, Ronald shows that VR makes it possible for other investigators to analyze the crime scene as well. This makes it possible to critically analyze the scene, as different investigators can focus on different types of evidence. As evidence loss is reduced in a virtual environment and different perspectives can be concerned, the negative effects of the contextual bias are reduced with VR (Gibson et al., 2000).

## *2. Education*

Apart from seeing the scene through multiple perspectives and the storage of evidence, “VR can be used for educational possibilities” (Ronald, appendix 1). Research suggests that education could reduce cognitive biases, if the focus of education is on cognitive processes of that bias (Burke, 2005). For the contextual bias, education should focus on providing the user with new information when walking through a crime scene. VR trainings might make officers more aware on this bias, as “trainings in VR are like experiences” (Ronald, appendix 1). By letting police officers experience certain biases or different perspectives, they might become more aware of these biases in general (Burke, 2005).

## ***Confirmation bias and tunnel vision***

### *1. Evidence collection and multiple perspectives*

One of the main problems concerning cognitive fallacies in criminal investigation is the confirmation bias (Bitzer et al., 2016). The confirmation bias leads to tunnel vision, resulting in wrong convictions (Rossmo, 2008). The main reason this bias occurs, is because evidence is overlooked. In order to reduce this bias, evidence has to be collected more carefully and seen from different points of view (Keith, 2006). This implementation is very similar to the

implementation for reducing the contextual bias described before. For the confirmation bias, Ronald illustrates how this is useful:

“And others can also have a look. If you’re going to the crime scene as a team, others might be not there. And when everything is done, you are lucky to still have the pictures. But you only have pictures” “And with VR, if police officers say: we cannot solve it, then another team or other colleagues will be able to watch [...] If you look at what you see, we can subsequently compare what we have found and what you have found. And with that you might prevent a problem like tunnel vision” (Ronalds, appendix 1).

## *2. Opposing arguments and devil’s advocacy*

Scientists have found that exposure to opposing perspectives together with counterarguments reverse the effect of the confirmation bias (Burke, 2005). If decisions made in the investigation are critically analyzed multiple times, for example by different persons or from different perspectives, tunnel vision is less likely to occur (Burke, 2005). An effect that is proven to reduce confirmation bias is that of devil’s advocacy: if people, for example police officers, are forced to give arguments that contradict their own beliefs, confirmation bias is reduced (Burke, 2005). For stage 2 (investigators  $\leftrightarrow$  eyewitnesses), this might be of help as eyewitnesses can relive the crime scene from multiple perspectives or multiple scenarios’ (Gibson et al., 2000). By letting eyewitnesses actively walkthrough the scene, eyewitness testimonies are of better quality as witnesses come up with less false information (Timmer, 2016). Apart from that, as the flaw in stage 2 focuses on the information perception of the investigator, the investigator can critically think of other scenarios with the use of VR. By doing so, the confirmation bias can be reduced (Burke, 2005). This effect can also be used for stage 3: DNA collection. By letting forensic examiners walkthrough the crime scene, seeing it from different perspectives, the confirmation bias is reduced as they are able to form a more objective point of view concerning the crime and crime scene (Sagana, 2006).

Also, VR makes it possible for multiple investigators to discuss what happened even after a long period of time. If one investigator has a strong vision on what happened and on someone’s guilt, “there is still the possibility for other investigators to look at evidence and walkthrough the VR scene” (Ronald, appendix 1).

## ***Limited time and capacity***

### ***1. Learning and reduced cognitive load***

Another problem that comes with the crime investigation is that of limited time and capacity. This problem gives rise to stress and wrongful convictions (Ditrich, 2015). In order to reduce this problem, a tool that enhances learning is required (Gibson et al., 2000). This can be done by providing less information or by making the information less difficult to process (Burke, 2005). Research done by Dalgarno et al. (2010) shows that when using VR, spatial knowledge representation, experiential learning and contextualization improve compared to 2-D representations. If learning happens faster in a virtual environment, it causes less stress compared to traditional cases (Dalgarno et al., 2010). By doing so, there is more time for the investigator to explore the crime scene, creating a bigger capacity compared to traditional methods (Gibson et al., 2000).

Another similar method of improving time and capacity is that of reduced cognitive load. Having a 'self avatar' in an immersive virtual world influences the participant's perception, presence and interaction (Steed et al., 2016). This study is based on recent theories that showed that participants were able to off-load mental tasks in the physical world because of visual feedback. One of these theories is that of *enactive cognition*, which states that cognition occurs as an interaction between the self and the environment (Steed et al., 2016). Seeing one's own body might therefore influence cognition in a positive way (Ma et al., 2010). Therefore, it is thought that virtual embodiment might reduce cognitive load (Steed et al, 2016). In the study of Steed et al., (2016), participants were asked to memorize pairs of letters. After the memorization they were asked to do a spatial rotation task and recall the memorized letters. The participants that were connected with a virtual avatar outperformed the participants without a 'self avatar'. Also participants that were allowed to move their hands while memorizing showed higher performance results (Steed et al, 2016). By seeing an actual virtual body in the VE, participants associated more with gestures and movements made in the VE (Steed et al, 2016). This shows that the effect of moving and identifying with a virtual body in the virtual world improves cognition and reduces cognitive load.

### ***2. Multiple Perspectives***

One of the other effects VR has on cognition is that of creating different perspectives through virtual embodiment (Cornet et al, 2019). Apart from transporting the user to another world, VR

also has the ability to transform one's body to another body (Ma et al., 2010). This creates the ability to change gender, ethnicity and experience this through virtual embodiment. VR also lets the user engage in behavior that is associated with the embodied avatar in the virtual environment (Cornet et al, 2019). This is called the 'proteus' effect, and occurs when the characteristics of a body shares are associated with behavior (Cornet et al, 2019). This effect is best explored in the research done by Seinfeld (2018). VR was used to let offenders of domestic violence experience domestic violence through a female body. Their emotional recognition skills were measured before and after the virtual embodiment, by measuring their ability to recognize fearful faces. Results of this research showed that cognitive recognition increased after virtual embodiment (Seinfeld, 2018). This research shows that VR has the ability to change one's social perspective through experiencing a specific action in a virtual environment.

### ***Selective Retelling***

#### ***Virtual context reinstatement***

The problem of selective retelling comes from the fact that memory retrieval is often not accurate and memories get lost over time (Rossmo, 2018). Therefore, eyewitnesses tend to come up with selective, unreliable convictions (Timmer, 2016). Research done by Timmer (2016) shows that VR might be a tool to reduce this effect by virtual context reinstatement. Context reinstatement is the act of bringing back memories that were created in a certain context by bringing the subject back to this context (Timmer, 2016). This can be done in three ways: physically by bringing the eyewitness back to the crime scene (physical context reinstatement). Secondly, there is mental context reinstatement, in which the witness is asked to remember the event mentally. Third, there is virtual context reinstatement, using VR techniques to bring back the memories in an accurate, virtual manner. Timmer's research shows that virtual context reinstatement has a positive effect on the quality and reliability of eyewitness testimonies. Participants that experienced full virtual context reinstatement came up with less false information (Timmer, 2016).

## **4. Application: limitations and considerations**

In this section the practical application of VR within the crime scene investigation is explored, focusing on the usability of VR for police officers. It should be taken into account that VR can also be applied in the other stages, such as in eyewitness testimonies (Timmer, 2016), in courtrooms (Schofield, 2007) and in forensic settings (Nakhaeizadeh, 2015). However, since police officers form the center of the distributed cognition, VR might be of most importance in stage 1: the crime scene reconstruction. Therefore, this section is specifically concerned with the application of VR for police officers. Apart from the context in which VR is applied, this section also looks at *practical rules* that need to be taken into account when applying VR. Information concerning these applications is gained from the expert-interviews.

### **4.1 Practical and Ethical Considerations: The Future of VR**

VR is a very powerful and might be a promising tool to reduce cognitive flaws. However, expert Liza explains it is important that the application of VR is carried out in an accurate manner:

“One of the main questions VR has to deal with, is that of effective representation. This issue is comprised in what is called the ‘grammar of VR’: “The grammar of VR includes the rules for making good, effective content. [...] One way to do this is to form a team consisting of VR researchers, VR end users and VR developers. By doing so, for each situation it can be decided whether VR is a good solution or not. It is important to create more insights regarding VR, as it is not a panacea. If you use it, do it well and safely” (Liza, appendix 1).

VR should not be seen as a replacement of traditional research, but as an addition instead. As Liza points out: “We still know too little to make use it as a replacement for traditional research. For some situations you might want to pick VR, for others the traditional methods are better” (Liza, appendix 1). This perspective is supported by Ronald, who compares using VR with entering a roller-coaster:

“If you visit an amusement park and you want to enter a rollercoaster, you will come across a very large sign at the start of the journey. This sign tells you that, to enter the roller coaster, you cannot be pregnant, you cannot have heart problems, you cannot have epilepsy and you must have a certain length. And so on. [...] This is the same for VR. If you read the fine print of VR

glasses, you will be shocked. There are so many side effects, but we use it anyway” (Ronald, appendix 1).

Liza states that VR might be very useful, but it should never replace the traditional manner. “We have years of experience with the traditional methods, for example when going to the crime scene. Relying on a new method like VR entirely can be quite risky” (Liza, appendix, 1).

However, according to Ronald, VR might be used according to the 80-20% rule: “80% of all trainings at the police academy can be carried out in VR. However, there still is the need to train in real life as well” (Ronald, appendix, 1). Both experts agree that VR should never replace the traditional manners, but become an added tool for the police.

Another more ethical consideration is that of trauma. Again, “VR is not a tool for everybody; it is not a panacea” (Liza, appendix 1). This is a point that is also depicted by Ronald: “If you have a colleague who has been through a lot, and you put him in a virtual environment that is pretty intense, this person might be more sensitive for developing PTSD” (Ronald, appendix 1). Risks like these still need to be further investigated.

It is also important to look at privacy consequences. Liza explains: “The glasses used for VR are commercial equipment. Data can therefore possibly also go to third parties. Oculus is from Facebook. Vive is from HTC, well these are large companies that also collect data when it comes to cellphones” (Liza, appendix 2). This shows the importance of keeping the ‘digital fingerprint’ that is made from all users safe.

## **4.2 Limitations and Further Research**

VR might be a tool that solves part of the fallacies discussed in the previous section. However, in order to provide a comprehensive understanding, it is important to explore the limitations of VR as well. One of the main considerations that both experts mentioned is that there’s still a lot to be learned about VR. Research is still insufficient concerning the limitations VR has on cognition. However, some research already shows limitations. These limitations include effects of overstimulation, the uncanny valley and motion sickness and will be discussed below.

### *Overstimulation*

VR might be a helpful solution when it comes down to reducing several biases, such as reducing cognitive load by learning enhancing (Steed et al, 2016). However, there might be a downside of

learning in VR, as Liza points out:

“ I recently came across a study that showed that VR can also have a negative effect on learning, because you can be very distracted by what you see in that environment. So a kind of over-stimulation takes place, which actually destroys learning. So I think it is a misconception that VR supports learning ability per definition. That is not the case, if it is not well developed it can have a bad influence on learning compared to traditional methods” (Liza, appendix 1).

This insight is very important when it comes to VR and learning, as over-stimulation might reduce the positive effects it has. This insight is also shown in research done by Makrasky et al (2019). Their research compared learning performances of students entering VR with a high level of immersion to students using VR with a low level of immersion. Results showed that students using a high level of immersion were more present in the virtual environment, but had a significantly higher cognitive load and learned less (Makrasky et al, 2017). This shows that using VR could also negatively influence learning.

#### *Uncanny valley and motion sickness*

Having a self-avatar and using virtual embodiment to enhance presence is seen as a tool to reduce cognitive load (Steed et al., 2016). Research states that one of the biggest challenges VR has is that of creating presence (Brey, 1999). VR experiences can be very intense, as the user is ‘locked up’ in the virtual environment. When entering a virtual environment, this environment can be perceived as reality (Cornet et al., 2019). The term Uncanny valley, first introduced by the Japanese in 1970, is an example of an important term that shows that presence in VR is not always created in the right way. Uncanny valley is the phenomenon that avatars, that are very similar to human beings, can be experienced as creepy (Cornet et al., 2019). Uncanny valley shows that the amount of realism of an avatar might not always improve the experience of the user (Cornet et al., 2019).

Also, entering a world in VR might not enhance cognitive load, but instead creates motion sickness (Akiduki et al., 2003). Motion sickness occurs when there is a visual-vestibular conflict, and is induced by using VR (Akiduki et al., 2003). It is therefore important to note “VR is not a tool that is useful for everybody” (Ronald, appendix 1). In order to fully understand the possibilities of VR, more insights must be gained by continued research.



## 5. Conclusion and Discussion

### Conclusion

The aim of this research was to gain more insight concerning what impact VR has on cognitive factors in criminal investigation. To answer the question, this research was divided into three parts. First of all, this paper showed how cognition is involved in the criminal investigation. Criminal investigations can be seen as a distributed cognition, in which decisions are made by multiple agents in each stage (Baber, 2006). Secondly, the cognitive fallacies were explored. This paper showed that fallacies involved in criminal investigation are: contextual bias, confirmation bias and tunnel vision, selective retelling and limited time and capacity (Burke, 2005). Thirdly, it was investigated how VR could be used as a tool to reduce these fallacies: VR enhances learning (Dalgarno et al., 2010), reduces cognitive load (Steed et al., 2016) and creates multiple perspectives (Keith, 2006). Besides, VR makes it possible to ‘freeze’ a crime scene for a long time and to keep evidence (Howard et al., 2000). However, there still are many aspects of VR that need to be investigated. As VR might have negative effects on learning (Makransky et al., 2017) and over-stimulation can take place, further research is required. Besides, there are practical considerations when applying VR. These are considerations of software representation, unaware side effects and privacy. In conclusion, VR might be an outcome to reduce fallacies that occur in criminal investigation. However, as noted: VR is not a panacea: it is not a replacement of traditional methods. Rather, it should be seen as an extra tool used to improve the reliability of crime scene investigation.

### Discussion

“I know that I know nothing”, an expression made by ancient philosopher Socrates (Leshner, 1987), illustrates an important critical note for this research. When studying the brain, or studying a tool like VR, there is one certainty: how much is still *not* known. However, pointing out what is *not* known, or what should be further investigated, is crucial for scientific progression. As VR applications are still scarce, it is important to critically reflect on the conclusions made. First of all, this paper was based on literature analysis. However, to study the effects VR has in practice, it is important to conduct experimental research. This literature-based research gave an overview of VR influences that might reduce the cognitive fallacies. However, in order to fully understand the effectiveness of VR, experimental research into each fallacy would be required. Secondly, only a part of all possible fallacies and VR influences was

discussed. To understand all the effects VR might have on cognition, a more extensive overview is required. Third, this paper focused on the investigator's role in the criminal investigation. However, the other stages in the investigation might be of equal importance. Therefore, a similar research for each stage, together with a research that integrates the conclusions of the different stages, is required. Apart from these further requirements, this research was one of first to investigate cognitive fallacies in crime scene reconstructions. It demonstrated the importance of conducting research into VR in police context by investigating the intersection of cognition and police practice: it demonstrated that VR will indeed become, and already is, a promising tool for criminal investigation.

## Literature

Akiduki, H., Nishiike, S., Watanabe, H., Matsuoka, K., Kubo, T., & Takeda, N. (2003). Visual-vestibular conflict induced by virtual reality in humans. *Neuroscience letters*, 340(3), 197-200.

Alison, L., Doran, B., Long, M. L., Power, N., & Humphrey, A. (2013). The effects of subjective time pressure and individual differences on hypotheses generation and action prioritization in police investigations. *Journal of Experimental Psychology: Applied*, 19(1), 83.

Ask, K., & Alison, L. (2017). Investigators' decision-making. In *Forensic Psychology in Context* (pp. 35-55). Willan.

Baber, C., Smith, P., Cross, J., Hunter, J. E., & McMaster, R. (2006). Crime scene investigation as distributed cognition. *Pragmatics & Cognition*, 14(2), 357-385.

Baddeley, A. D. (1997). *Human memory: Theory and practice*. Psychology Press.

Brey, P. (1999). The ethics of representation and action in virtual reality. *Ethics and Information technology*, 1(1), 5-14.

Bitzer, S., Ribaux, O., Albertini, N., & Delémont, O. (2016). To analyse a trace or not? Evaluating the decision-making process in the criminal investigation. *Forensic science international*, 262, 1-10.

Bronkhorst, L., S. M. S., & Nijboer, J. A. (2014). *Politiële tunnelvisie, kan het worden voorkomen?* Scriptie Master Strafrecht en Criminologie.

Burke, A. S. (2005). Improving prosecutorial decision-making: Some lessons of cognitive science. *Wm. & Mary L. Rev.*, 47, 1587.

Chisum, W. J., & Turvey, B. E. (2011). *Crime reconstruction*. Academic Press.

Cornet, L. J. M., den Besten, A. L., & van Gelder, J. L. (2019). *Virtual Reality en Augmented Reality in justitiële context*.

Dalgarno, B., & Lee, M. J. (2010). What are the learning affordances of 3-D virtual environments?. *British Journal of Educational Technology*, 41(1), 10-32.

Decorte, T. Zaitch, D. (red.) (2016). *Kwalitatieve methoden en technieken in de criminologie* (3de editie), Acco.

- Dror, I. E. (2015). Cognitive neuroscience in forensic science: understanding and utilizing the human element. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 370(1674), 20140255.
- Ditrich, H. (2015). Cognitive fallacies and criminal investigations. *Science & Justice*, 55(2), 155-159.
- Gibson, S., & Howard, T. (2000). Interactive reconstruction of virtual environments from photographs, with application to scene-of-crime analysis. In *Proceedings of the ACM symposium on Virtual reality software and technology* (pp. 41-48). ACM.
- Howard, T. L., Murta, A. D., & Gibson, S. (2000). Virtual environments for scene of crime reconstruction and analysis. In *Visual Data Exploration and Analysis VII* (Vol. 3960, pp. 41-49). International Society for Optics and Photonics.
- Keith A. Findley; Michael S. Scott (2006). Multiple Dimensions of Tunnel Vision in Criminal Cases, *The , 2006 WIS. L. REV.* 291.
- Lesh, J. H. (1987). Socrates' disavowal of knowledge. *Journal of the History of Philosophy*, 25(2), 275-288.
- Ma, M., Zheng, H., & Lallie, H. (2010). Virtual reality and 3D animation in forensic visualization. *Journal of forensic sciences*, 55(5), 1227-1231.  
(Ma & Lallie, 2010)
- Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2017). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*.
- Nakhaeizadeh, S.; Dror, I. E.; Morgan, R. M. (2015). The emergence of cognitive bias in forensic science and criminal investigations. *British Journal of American Legal Studies*, 4(2), 527-554.
- Ross, D. Kim. *Criminal investigative failures*. CRC press, 2008.
- Sagana, A., Bacon, J. L., Kahneman, D., Trevski, A., Arkes, H., & Nisbett, R. (2018). The downward spiral of biases in criminal investigations: From eyewitnesses to forensic experts and judges. 'Vom hochgemuten, voreiligen Griff nach der Wahrheit': Fehltritte im Strafprozess, 56, 133.
- Schofield, D. (2007). Animating and interacting with graphical evidence: Bringing courtrooms to life with virtual reconstructions. In *Computer Graphics, Imaging and Visualisation (CGIV 2007)* (pp. 321-328). IEEE.
- Timmer, J. (2016). *Getuigenverhoor op de plaats delict: Een experimenteel onderzoek naar het effect van context reinstatement op de kwaliteit van getuigenverklaringen en het inschattingsvermogen van getuigen*.

Van Gelder, J. L., Otte, M., & Luciano, E. C. (2014). Using virtual reality in criminological research. *Crime Science*, 3(1), 10.

Virtual Lab: Polymerase Chain Reaction Virtual Lab | Labster. (n.d.).Photo. Consulted from <https://www.labster.com/simulations/polymerase-chain-reaction/>

## Appendix – 1

### *Interview Specifications*

Attachment 2: Interview specifications

#	First Name	Expertise	Time / Place interview	Name Permission	Informed Consent
1	Liza	<ul style="list-style-type: none"> <li>Liza is a neuropsychologist and works as a researcher at the University of Twente.</li> <li>Here she conducts research into the applications of VR within the judicial context.</li> </ul>	19th of June, 2019 09:00-09:35 By phone	<input checked="" type="radio"/> yes	<input checked="" type="checkbox"/>
2	Ronald	<ul style="list-style-type: none"> <li>Ronald is Chief of Digital Simulations at the Police Academy of the Netherlands.</li> <li>Besides he's chair of the National Network Digital Simulations</li> </ul>	20th of June, 2019 16:00-16:40 Police Academy, the Netherlands	<input checked="" type="radio"/> yes	<input checked="" type="checkbox"/>

## Appendix – 2

### *Topic-list Interviews*

Topiclijst Interviews	Topiclist Interviews
Dutch	English
<p><b>VR algemeen</b></p> <ul style="list-style-type: none"> <li>• Om te beginnen, zou u kunnen uitleggen wat VR is?</li> </ul> <p>Werking</p> <p>VR als medium</p> <p>Eerste toepassingen</p> <p>Relevante disciplines</p> <p>Positieve/negatieve effecten</p>	<p><b>VR in general</b></p> <ul style="list-style-type: none"> <li>•To start, could you explain what VR is?</li> </ul> <p>Operation</p> <p>VR as a medium</p> <p>First applications</p> <p>Relevant disciplines</p> <p>Positive/ negative effects</p>
<p><b>Toepassing</b></p> <ul style="list-style-type: none"> <li>• Hoe wordt VR toegepast in justitiële / politie context?</li> </ul> <p>Waar / wanneer</p> <p>Begeleiding</p> <p>Experts</p> <p>(extra) apparatuur</p> <p>Niveau (lokaal / nationaal)</p> <p>Vorbereiding justitie / politie</p> <p>Kosten / Tijd</p>	<p><b>Application</b></p> <ul style="list-style-type: none"> <li>•How is VR applied in a judicial / police context?</li> </ul> <p>Where/when</p> <p>Guidance</p> <p>Experts</p> <p>(extra) equipment</p> <p>Level (local / national)</p> <p>Justice / police preparation</p> <p>Costs / Time</p>
<p><b>Persoonlijke ervaring</b></p> <ul style="list-style-type: none"> <li>• Wat is uw eigen ervaring met VR binnen uw werkveld?</li> </ul> <p>Persoonlijke achtergrond</p> <p>Rapport justitiële context/ Politie academie</p> <p>Aanleiding gebruik</p> <p>Positieve ervaringen</p> <p>Negatieve ervaringen</p> <p>Aanleiding</p> <p>Context</p>	<p><b>Personal experience</b></p> <ul style="list-style-type: none"> <li>• What is your own experience with VR in your professional field?</li> </ul> <p>Personal background</p> <p>Judicial context report/ Police Academy</p> <p>Reason for use</p> <p>Positive experiences</p> <p>Negative experiences</p> <p>Reason</p> <p>Context</p>

<p><b>(Cognitieve) problemen</b></p> <ul style="list-style-type: none"> <li>• Wat zijn de huidige problemen binnen politieonderzoek /justitie onderzoek op het gebied van cognitie?</li> </ul> <p>Geheugen</p> <p>Cognitie (Bias, tunnelvisie, cognitieve lading)</p> <p>Gerechtelijke dwalingen</p>	<p><b>(Cognitive) problems</b></p> <ul style="list-style-type: none"> <li>•What are the current problems in the field of police / judicial investigation concerning cognition?</li> </ul> <p>Memory</p> <p>Cognition (bias, tunnel vision, cognitive charge)</p> <p>Judicial errors</p>
<p><b>Cognitie en VR</b></p> <ul style="list-style-type: none"> <li>• Hoe kan VR helpen om problematiek (rondom cognitie) binnen justitie/politie op te lossen?</li> </ul> <p>Wetenschappelijke rapporten</p> <p>Cognitieve ontwikkelingen</p> <p>Minder cognitieve load</p> <p>Goedkoper</p> <p>Herzien plaats-delict</p> <p>Trainingen</p> <p>Simulatie misdaad</p>	<p><b>Cognition and VR</b></p> <ul style="list-style-type: none"> <li>•How can VR help solve problems (related to cognition) within judiciary / police?</li> </ul> <p>Scientific reports</p> <p>Cognitive developments</p> <p>Less cognitive load</p> <p>Cheaper</p> <p>Review crime scene</p> <p>Trainings</p> <p>Simulation crime</p>
<p><b>Ethische kwesties</b></p> <ul style="list-style-type: none"> <li>• Wat zijn de ethische kwesties rondom de toepassing van VR?</li> </ul> <p>Acceptatie</p> <p>Representatie van de realiteit (software)</p> <p>Verdachten VR laten gebruiken</p> <p>Trauma</p>	<p><b>Ethical issues</b></p> <ul style="list-style-type: none"> <li>•What are the ethical issues surrounding the application of VR?</li> </ul> <p>Acceptance</p> <p>Representation of reality (software)</p> <p>Allow suspects to use VR</p> <p>Trauma</p>
<p><b>Besluitende vragen</b></p> <ul style="list-style-type: none"> <li>• Hoe ziet u de toekomst van VR in justitiële/politie context voor u?</li> </ul> <p>Toekomst omtrent VR</p> <p>Korte samenvatting</p> <p>Eventuele vragen/ toevoegingen respondent</p>	<p><b>Concluding questions</b></p> <ul style="list-style-type: none"> <li>•How do you see the future of VR in the judicial / police context?</li> </ul> <p>Future of VR</p> <p>Brief summary</p> <p>Any questions / additions</p>



## Appendix – 3

### VR influence on cognition overview

