Master thesis Business informatics

The hybrid theory in Practice
A case study at the Dutch police force

Universiteit Utrecht

POLITIE

Author

Nard Timmers
5511798

Supervisors (Utrecht University)
Dr. Floris J Bex
Prof. dr. mr. Henry Prakken

External supervisor (Dutch police force)
Daan Sutmuller

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1. Introduction

When someone is prosecuted for a crime, the prosecutor presents a series of events to the court which pleads that the suspect committed the crime. This series of events or story is supported by arguments and evidence. The presented story is the result of a police investigation. The police tries to eliminate all possible stories until one true story remains. If the created story cannot be proven wrong, then it is presented to the prosecutor. The prosecutor presents the story to a court. The suspect will try to present a story which is also possible but pleads that the suspect has not committed the crime. If the police and the prosecutor have done their jobs well, then they should have already found this story and they should have arguments and evidence which refutes the story of the defense.

For the reasoning with stories and arguments some theories have been proposed. One of these theories is the hybrid theory of Floris Bex [1]. The hybrid theory uses arguments and stories in order to find the true series of events. Bex demonstrates his theory using court cases. However, when a case is presented in court this is done at the end of a police investigation. All the evidence is already sorted and only two stories remain (the one of the prosecutor and the one from the defense). Reasoning can be done in a focused manner on only two stories. When the police just start their investigation there are many (vague) stories and the evidence might be scarce and scattered. How does the hybrid theory hold when the stories and arguments are vaguer? To test this, this thesis research was set up. In this research it is attempted to try to find how the hybrid theory holds in a police investigation and how the hybrid theory could be applied to the police practice.

1.1 Problem statement

The hybrid theory, created by Bex [1], could be a theory which might be compatible with the reasoning of the police. However, the police force of the Netherlands has implemented the analysis of competing hypotheses into their daily working procedure. Outside of the analysis of competing hypotheses, the police uses no other theories to support their work. A part of the work is done based on gut feeling and experience. This experience or gut feeling is hard to explain to prosecutors and other detectives. Introducing formal theories might make it easier to take people through the different steps of the investigation. The introduction of more formal theories such as the hybrid theory has not been done yet. This is probably caused by the fact that no comprehensive studies have been performed in which the hybrid theory or other comprehensive theories have been compared with the current working procedure of the Dutch police. Since there have not been any comprehensive studies there have not been any comprehensive tests whether other theories can be used by the police in practice. One of the reasons that this might not have been done is that the police is very careful with giving access to evidence of cases to people from outside of the police force. However, if theories are not tested, then the police will not use them. Therefore, the goal of this thesis study is to find out if the hybrid theory is usable in practice by the police.

1.2 Research approach

To see if the hybrid theory can be made into a usable method and if this method can be a useful apply in police investigations, the concepts of both the hybrid theory and the police practice have to be known. To structure the search for these concepts and to get answers to all the questions of this research, the following research questions are created.

1.2.1 Research question

The main goal of this research is to find out if the hybrid theory is usable by the Dutch police in their criminal investigations. The first main research question will be:

RQ1: "How do the hybrid theory and the working procedure of the police relate?"

Answering this question will give an image on the working procedures of the Dutch police and the hybrid theory. The answer to this question will give an overview of important features of the hybrid theory and the theoretical working procedures of the police and how these features of each theory compare to each other. This will be the result of the literature study. To understand the hybrid theory and the police theory sub questions 1.1 and 1.2 are proposed.

SQ1.1: What are the most important concepts in the hybrid theory and how are they related?
In order to compare the concepts of the hybrid theory with other theories, it is important to determine which concepts are the most important in the hybrid theory and how these concepts are related to each other.

SQ1.2: What are the most important concepts in the reasoning of the police and how are they related?
Just like with the hybrid theory it is important to understand what the important concepts are in the reasoning of the police and how they are related to each other.

The second main research question will be:

RQ2: "How can the hybrid theory be made into a method which can be put into practice by the police?"

The answer to this question will give a method that is applicable to crime cases at the Dutch police force. The main aim of this question is to look if a work method created with the hybrid theory is doable in practice. The question if the method is also easy to use is not important at the moment. If the hybrid theory is not able to solve a problem in practice, it might be necessary to add other theories to solve that problem. Therefore sub question 2.1 is created. When the hybrid theory is not able to solve problems in practice it is important to list the elements or practices that the hybrid theory misses. Therefore sub question 2.2 is created.

In order to answer the main research questions, the following sub questions need to be answered:

SQ2.1: Which other theories can be used combined with the hybrid theory in order to make it usable in practice?
When the hybrid theory does not provide a solution for a problem in practice, it might be possible to apply other theories in order to solve the problem.

SQ2.2*: What concepts and tools have to be added to the hybrid theory in order to put it into practice?*
When the method, which is developed with the hybrid theory, is put into practice concepts might arise which are not covered by the hybrid theory. These concepts need to be written down and discussed in order to see if they can be implemented into the hybrid theory or to at least discuss where the hybrid theory falls short in practice.

SQ2.3: What controls can be created to check if the same quality demands as the hybrid theory are present in the created method?

When a method is created to apply the hybrid theory in practice, it is important to check if the same quality demands for stories are present in the method as in the hybrid theory. Therefore the quality demands from the hybrid theory have to be made clear.

To compare the current concepts of the police with the concepts of the hybrid theory, the important features of both the hybrid theory and the current working procedure of the police will be compared. The hybrid theory will be put into a hybrid theory method with help of the police. This method of the hybrid theory will be tested on a solved case. One of the first things to do is understand how the police works.

How all these research questions will be answered is described in the research method.

1.3 Research method

To answer the research questions a research method is proposed. The research method is built up out of a literature research and a case study. To test the hybrid theory in practice the following research method will be used. The research method will exist of the following steps:

1. A literature research will be performed. In the literature research the hybrid theory, the police theory and other arguments and story techniques will be explained together with the role of stories and arguments in the hybrid theory and in the working procedures of the police. Next to the hybrid theory different relevant methods for reasoning about stories will be explained. The goal is to create a method out of the hybrid theory in order to test if the reasoning with evidence (arguments) and stories, as described in the hybrid theory, can be done in practice.

2. After the literature research it is important to see how the police reasons about crime now and which methods they use. This is the police practice and may differ from the police theories found in the literature study. For the theory about the police research the book "het recherche portret" [2] will be used together with an explanation of the investigation process by an analyst of the police. After the theory has been documented observations will be performed with analysts of the police who reason with evidence and stories on a daily basis.

3. From the results of the previous step a description of the current working method of the police divided into different steps will be made. This current working method will be used to compare to the hybrid theory in the next step.

4. The next step is to perform a case study using a self-made method based on the hybrid theory. For this case study a solved murder will be reinvestigated. Using the evidence gathered in this case the created method based on the hybrid theory will be tested.

5. After the case study a report will be made about the findings made during the case study. Improvements on the hybrid theory method will be suggested. The idea is to use different theories to improve the hybrid theory method.

The research is started with a literature study which looks into the hybrid theory and the police theory. This literature study should give the answer to the sub questions 1.1, 1.2 and 2.1, 2.3 and research question 1. The literature study should also give a theoretical hybrid theory method, called hybrid theory method 0.1. This method is based on the hybrid theory and will be the basis for case study.

This method will be tested in the case study. The case study will reinvestigate a solved murder case. The real evidence of this case will be used in the case study. This evidence is made available by the Dutch police force. The case study will give an answer to research question 2. The case study will result in an improved hybrid theory method, which will be called hybrid theory method 1.0. Sub question 2.2 will also be answered by the case study. The execution and results of this master thesis research will be described in this thesis. The structure of this thesis will be explained in the next section "1.4 thesis structure".

1.4 Thesis structure

This thesis is structured in the following manner. In chapter 2 the literature research is presented. In this chapter the hybrid theory is explained as well as the theories which are in use by the police. The end of this chapter proposes a method, based on theory, which will be tested in practice in the case study. Chapter 3 gives an overview of the case study. In this chapter the police practice is described. After this description a step-by-step overview of the case study with the hybrid theory method is shown. The end of chapter 3 proposes an improved hybrid theory method, which has been improved using the practice of the case study. Chapter 4 will recapitulate the whole thesis study and describe the results. After the results the thesis study will be placed in perspective and the results will be looked at critically. In the end of this chapter future research is proposed.

2 Literature study

As mentioned in the research method the aim of the literature research is to understand how a police investigation works in theory and on which theories an investigation is based. The aim of literature study is also to understand the hybrid theory and see which concepts are important for this theory and how these concepts are related. When the police theory and the hybrid theory are known they can be compared in order to see how they relate and this will answer RQ 1.

2.1 The theoretical working procedures of the police

When a crime is committed the police starts an investigation. Depending on the type of crime detectives will gather evidence from the crime scene. When this evidence is gathered analysts will start working on the case. From this point the working method will be described. This point is chosen because from this point it is possible to start with the hybrid theory method. The hybrid theory method is a method based on the hybrid theory. This method will be discussed in detail in the chapter 2.6. The collection of evidence and how this is done is not part of this research; therefore the starting point will be after the gathering of evidence. How the police works in theory and which theories they use is partly based on the book "het recherche portret" [2] and a theoretical example from an analyst from the police. There are two kinds of police analysts working on a case:

- Operational analysts, who work closely to the murder scene. Investigates things like call history and other data and statements. Their main task is give an overview of all the data gathered in the investigation
- Tactical analysts, who form hypotheses and scenarios based on the findings done by the operational analyst. Their main task is to use the data to manage the investigation.

This research will focus on the tactical analysts since they work with scenarios and arguments. The hybrid theory method will be applicable to their work and therefore the comparison will be done with their current working method.

The analysts of the police use four different software programs to aid them in their investigation. These programs help them structure their thoughts and evidence. The first program they use is called Summ-it. This program is used to register evidence. Summ-it can order evidence by date and person.

The second program is called X-mind. X-mind is mind-mapping software which helps organize the investigators thoughts and findings. X-mind is used with a template which divides the information in two categories: facts and events. These facts are the facts of the crime committed, and include things like crime location, date of the crime, the victim(s), eyewitnesses and possibly the used weapon(s). The events handle possible scenarios about what could have happened. These events include scenarios like natural or unnatural death, robbery, murder or manslaughter. There is also a possibility that scenarios overlap. For each scenario

the pros and cons are registered in X-mind. Figure 1 shows an example of a mind map build-up in X-mind.

Figure 1: X-mind example.

The third program is called Analyst's Notebook. Analyst notebook allows analysts to create timelines with evidence linked to different events on the timeline. The program is also used for modeling relations between the victim and all the persons in the investigation.

The fourth piece of software is made by internally by an analyst of the police. It is an Excel sheet combined with VBA (Visual basic for applications) scripts and it is often referred to as a weighted subject list. This program allows the analysts to order suspects in order of importance. The suspects obtain a score based on different attributes like do they have an alibi, were they at the scene of the crime, do they know the victim and so on.

2.2 Making sense of information

Before stories and arguments are explained it is important to look at the way that people create knowledge out of information. Creating knowledge from information and how to create presentable information (stories or arguments) from loose information is the basis for this thesis research and needs to be explained.

Pirolli and Card [3] have described a process for making sense of data. This process can be driven bottom-up (data to theory) or top down (from theory to data). As seen in figure 2, Pirolli and Card have divided their process in two loops of activities, a foraging and sense-making loop.

The foraging loop involves seeking, filtering, reading and extracting information. Seeking involves the searching for information or data. Filtering means going through the found information and judging how relevant it is. Reading means going through the found data and when interesting information is found, extracting it from the data. This extracted data is placed into schemas. Examples of these schemas are timelines or small stories.

The sense-making loop involves the iterative development of a mental model (a conceptualization) from the schema that best fits the information. The sense-making loop starts with schematizing the extracted information found in the extracting step. This does not have to be a very complicated schema; the most important goal of this schema is that the information is organized. Pirolli and Card suggest that information is organized in small-scale stories about topics such as who, what, when, where, why and how. The next step is building a case. This step involves building a theory or case with evidence. This is done in order to support or disconfirm hypotheses. The last step is telling the story. In this step the created story is shared with relevant stakeholders.
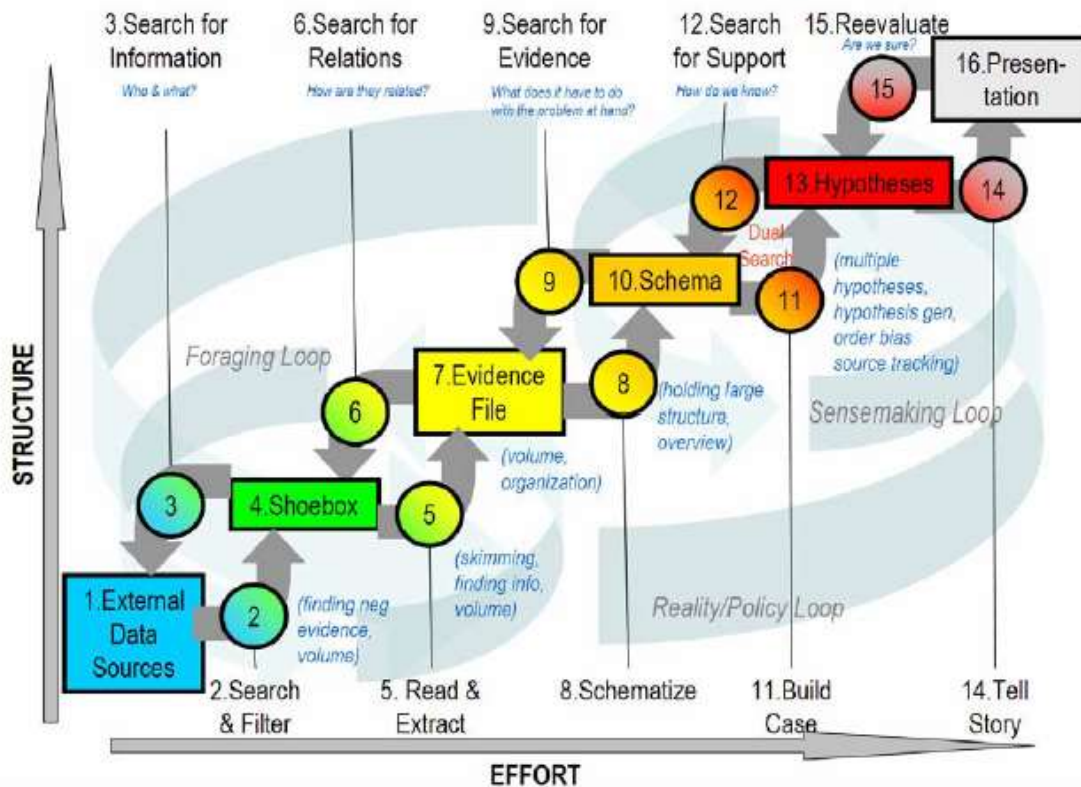
Figure 2: the sense making process. [3]

Although Pirolli and Card explain how data can become a theory or story, they do not explain what a story or argument needs in order for them to be understandable and usable in the sense making process.

The police uses scenarios to solve crimes. These scenarios have to be compared in order to find the best scenario. The best scenario explains what has happened in a logical manner and is supported by evidence. To find this best scenario many theories have been developed. These will be discussed in this literature research. The main theory that is discussed is the hybrid theory by Bex [1]. This theory will be discussed first. In this literature research the case of Nadia van der V. is used to illustrate certain aspects of stories and arguments. Nadia is found in her student house. She was shot from close range. Her landlord is de main suspect in this case. He was at the house at the time of the death of Nadia. He had an argument with Nadia before she died.

2.3 Hybrid theory

According to the hybrid theory of Bex [1] stories and arguments are necessary in order to reason about what has happened at a crime scene. When a crime has been committed, stories are created based on the found evidence. These stories or hypotheses try to explain what has happened at the crime scene. This section will give an answer to sub question 1.1.

2.3.1 Stories

Stories are created in order to tell a series of events and to make events comprehensible. A story explains the causal relation between the different events that have occurred. These different events form a timeline which helps giving a clear overview on what has taken place and in which order.

A story is a coherent sequence of events in chronological order. Stories have a distinct structure. Stories can be structured in story schemes. The best-known story scheme is the simple scheme of beginning, middle and end. However, this scheme is very general and leaves a lot of place for personal interpretation by the person who creates the story. For the example of Nadia, the story would consist of the following events: "Nadia and the landlord have an argument, the landlord becomes enraged, the landlord takes his gun, the landlord shoots Nadia in the head and Nadia dies". This sequence of events is shown in Figure 3.
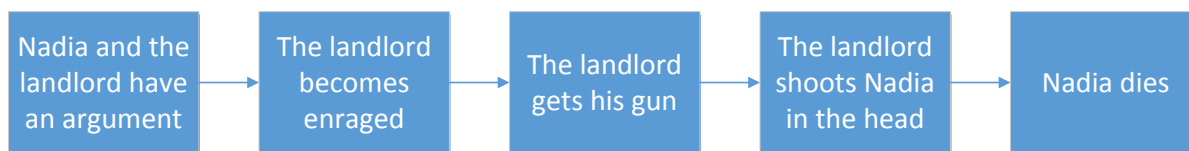

Figure 3: story as sequence of events

Schank and Abelson [4] created detailed story schemes that are schemes for stories in a certain context. An example of such a scheme is the standard pattern that happens when someone visits a restaurant. This scheme will always contain a customer going into a restaurant, sitting down, ordering food, a cook who cooks the food, a server who brings the food and the customer who will eat the food and pay for the food.

These schemes can be used as a template for certain situations. They can help with identifying the different components which need to be filled in in order to complete the story.

For example, when a murder has occurred the police needs to identify the murderer, the victim, the murder weapon and so on. Thanks to the story scheme of a murder it is possible to identify all these concepts which are needed to fill in the story of a murder. For the Nadia case analysts of the police try to make stories or scenarios of what has happened. They find Nadia with several bullet holes in her head in her student house in Utrecht. Using the story scheme of a murder the analyst knows what the elements are they need to explain what has happened. So in this case they need a murder weapon, which is probably a gun, and a suspect who has shot Nadia. This scheme will help the analyst to make a complete story since he can fill in the scheme for a murder story. Completeness for stories means that there are no gaps in the story. Having a complete story will make the story easier to follow.

2.3.2 Arguments

Anderson and colleagues describe arguments as a chain of defeasible inferences or a chain of reasoning [5] [6]. This chain of defeasible inferences can be based on evidence which can then be used to support or attack the individual facts in the stories. This defending (giving support) or attacking of parts of the story with

arguments is described by Bex [1] and will be explained later in this chapter. Anderson and colleagues mention that the chain of reasoning can show the reasoning behind the reasoning. This means that a chain of reasoning not only shows the reasoning itself but also why this reasoning is applicable in the give situation. This will help give insight in why certain arguments do or do not apply in a specific case. Arguments are often based on evidence or generalizations.

Van Eemeren and Grootendorst [7] also mention that argumentation should be based on forms of reasoning which are natural to and used by humans. This will help understand the arguments. The understanding of an argument can help with accepting an argument. A generalization is knowledge accepted by a certain community. This is knowledge such as "if a person falls from a great height he or she dies". Generalizations can help explain why certain arguments support parts of the story. An example of a generalization is that "psychiatrist's reports are usually correct about people's psychological issues". Generalizations can be used as a warrant. This means they support the application of evidence or a generalization to a certain event. For the murder of Nadia, we could say that a psychiatric report that claim the landlord can have rage attacks can support the event that the landlord becomes enraged. The generalization that "psychiatrist's reports are usually correct about people's psychological issues" is warrant that this report can be used because it is usually correct. The relation between evidence and the warrant is shown in Figure 4.
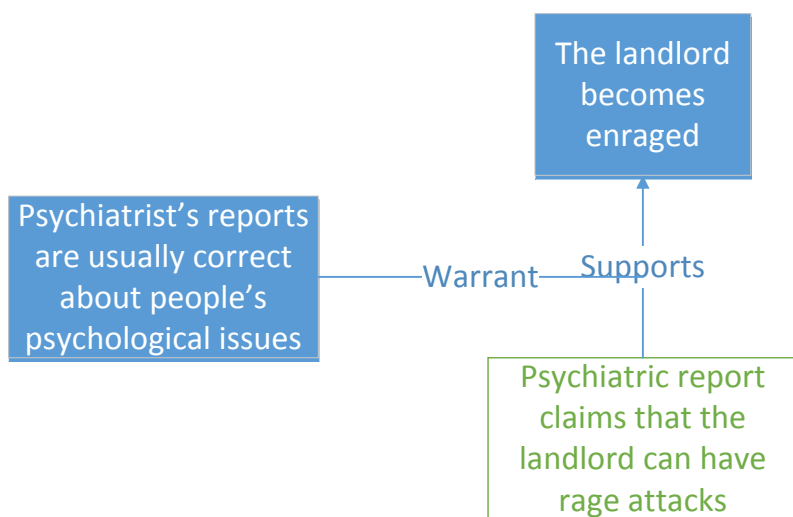
Figure 4 Evidence supporting an event together with the warrant for the use of the evidence.

It is also possible that an argument supports that one event can follow from another. For the Nadia case this would be the landlord shoots Nadia in the head which leads to Nadia dying. That this shooting leads to dying is supported with the generalization which claims that people who are shot in the head often die. The warrant for this generalization is medical data which claims that headshots are very lethal. This is shown in Figure 5.
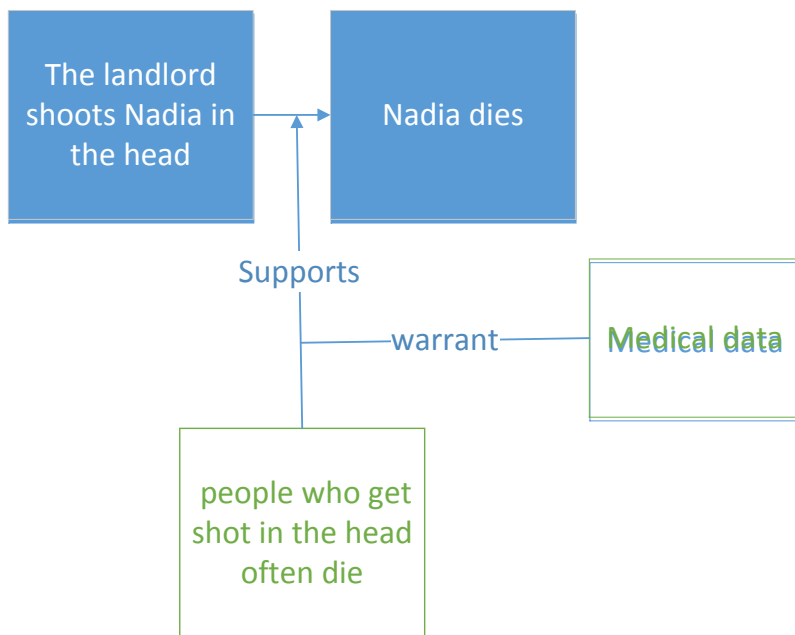
Figure 5: Evidence supporting events following each other. With a warrant supporting the application of this evidence.

 To see whether an argument is good it is possible to use an argumentation scheme. Argumentation schemes are, just like story schemes, patterns to help create arguments. An argumentation scheme shows a general pattern of reasoning that underlies an argument. For example, in the Nadia case the analysts want to show how they come to their conclusion that the landlord has killed Nadia. The analysis for example show evidence that the landlord has and anger issue. This is supported by reports of a psychiatrist who has examined the landlord. This report is evidence that supports the landlord who becomes enraged and kills Nadia.

Evidence plays an important role in argumentation. It is therefore important to understand what inferences can be made from evidence. Evidential data is the primary source of evidence in a case [5, p. 382]. Bex [1] mentions that there is an important difference between evidential data and the propositions inferred from this evidence. To show the difference the example of Nadia is used. The report of the psychiatrist about the landlord's anger issues is evidence which is further indicated as "E*"and the event of the landlord having a rage is indicated as "E". In this example E* is thus the evidential data about event E. Bex mentions that the difference between these two is important because having evidential data E* does not automatically mean that event E has taken place. Therefore the example of Nadia, the report that the landlord has anger issues does not mean that he had and anger issue.

The reasoning with arguments means that the argument is attacked or supported by other arguments, the argument can then be defeated or be non-overruled. An argument can be defeated by either attacking the argument itself, the source of the argument or the application of the argument on the case at hand. A non-overruled argument is an argument that has no more counterarguments, or for which all of the counterarguments have been defeated.

2.3.3 Combining stories and arguments

Looking at stories and arguments, the main difference is that stories show the causal relations between events and arguments show the evidential relations between premise and conclusion. Stories show causal relation between events, this relation can be expressed as A causes B. Arguments are the evidential proof of an event and this proof can be expressed as B is evidence for A. An example of Nadia's murder story is: "Nadia and her landlord have an argument. The landlord becomes enraged. The landlord goes and takes his gun. The landlord shoots at Nadia. Nadia dies." These are all events which cause a next event to happen. For example, the landlord having an argument with Nadia leads to the landlord becoming angry. The arguments for this story are a "psychiatric report that claims the landlord has anger issues" and "statistics that people who are shot in the head die".

The main idea of the hybrid theory is that it is possible to reason about stories with the help of arguments. The ideal story is a story where each decision or action taken by a character or the world can be supported by an argument. This argument ideally went through the reasoning with arguments and is therefore non-overruled.

Arguments in the hybrid theory have as their main goal to give evidence for the different events and why one event leads to another. For example, if a person is shot in the head then he has a big chance of dying. This will be backed up by for example, statistics stating that people with holes in their head die. These statistics would be a generalization.
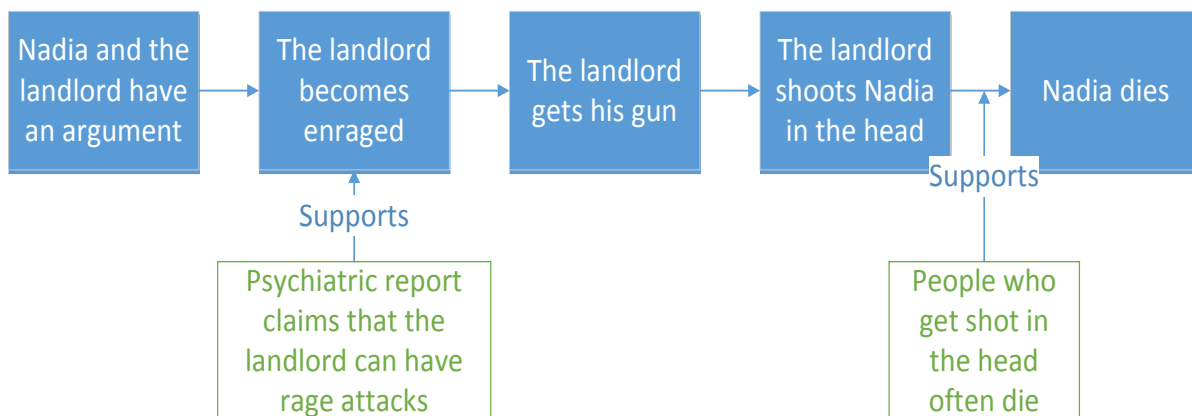
Figure 6: stories and arguments

As seen in figure 6 evidence can be evidence for the causal relations between events or for the event itself. For example, the psychiatric report is an argument for the event that the landlord became enraged. The argument (generalization) that people who are shot in the head often die is an argument that shooting someone in the head can lead to this person dying.

2.3.4 Critical questions

In order to determine the quality of the presented stories and arguments used in the hybrid theory Bex and Verheij [8] have proposed six critical questions. These questions can be used to critically check the presented arguments and stories. These six questions help to put the hybrid theory into practice. They help to implement and apply the important aspects of stories and arguments according to the hybrid theory on stories and arguments. These six questions will be discussed below.

1. **Are the facts of the case made sufficiently explicit in a story?**

The aim of the first question is to find out if a story is comprehensible and if the facts in this story are sufficiently made explicit.

2. **Is the story sufficiently supported by evidence?**

The second question is meant to check whether all the important parts of the story are supported by evidence. As mentioned before each important part of the story has to be backed up by arguments in order to be able to check the story.

It can happen that there is no direct evidence for an event in the story. This is called an evidential gap. Filling these gaps can be done by using events in the story which are supported by arguments. When we have these supported events we can use these supported events to infer what happens in the evidential gap. Evidential gaps are often created in order to make the story more coherent. However, making a story more coherent may not become more important than supporting the story with evidence. The aim is to create a true story based on evidence were there are as few gaps as possible, not a story that is as coherent as possible without any support.

3. **Is the support that the evidence gives to the story sufficiently relevant and strong?**

This question is devised to think about the different pieces of evidence which are presented during an investigation. Not each piece of evidence is equal, some pieces of evidence can be irrelevant for the story or some pieces of evidence can be weaker than other pieces of evidence which is presented during the investigation. This question also has two sub questions:

   (a) Are the reasoning steps from evidence to the facts in the story justified by explicit warranting schemes or generalizations that are valid and grounded?

This sub question refers to the argumentation schemes and generalizations which are mentioned before. The sub question demands if there is a clearly described path of reasoning so the choices for different arguments can be explained.

   (b) Are there exceptions to the use of the schemes and generalizations that undermine the connection between evidence and facts?

This sub question helps the analyst to think critical about the links between the evidence and facts. This link is described earlier as the warrant. The sub question makes the analysts look at the given warrant and makes him question it. Is this warrant applicable in this case and is the warrant correct?

4. **Has the story itself been sufficiently critically assessed?**

The fourth question is made to critically asses the given story. There are three sub questions to help give direction to the critical assessment. These sub questions give points which can be used to critical asses the story.

   (a) Is the story sufficiently coherent? Are there elements missing? Are there implausible events or causal relations? Is the story inconsistent?

According to Pennington and Hastie [9], Wagenaar et al. [10] and Pardo and Allen [11] stories are coherent sequences of events. Bennet and Feldman mention that the coherence in a story plays a big part in whether people believe the story or not [12]. Pennington and Hastie [9] have looked into what makes a story coherent. They came up with three quality criteria for the coherence of a story: Consistency, which means a story does not contradict itself. Plausibility, which means that a story has to believable for the readers or listeners, based on what they know of the world. Completeness, which consists of the story being complete and not missing steps. As mentioned before story schemes can help with creating complete stories by guiding the analyst.

(b) Is there evidence that refute elements of the story?

This sub question looks at the story and the evidence at hand to see if there is evidence that proves that certain elements of the story cannot happen according to the evidence.

(c) Have story consequences been used to test the story?

The third sub question mentions the term story consequences. Story consequences are logical events which should also take place when the presented story would be true. This means that for a story to be true, all the consequences of this story should also have happened. For example, when a story tells that someone was murdered, the story consequence should be that there is a body.

5. **Have alternative stories been sufficiently taken into account?**

The fifth question looks at the alternative stories for the presented story. Alternative stories have to be taken into account in order to have covered all the potential alternative explanations. The sub questions try to give certainty in the amount of research and effort that has been put into the investigation of the alternative stories. If alternative stories have not been taken into account sufficiently then there is a risk of having tunnel vision or missing alternatives which fits the evidence better.

(a) Has a sufficient search for alternative explanations been performed, not only in the investigative phase, but also in court?

This sub questions demands that alternatives have been taken into account during the whole of the investigation. This is to make sure that investigators keep an open mind during the whole of the investigation

(b) Have the alternatives been sufficiently analyzed? Are there explicit reasons to choose one story over the alternatives?

This sub question supports the previous one by asking if the alternatives have been taken seriously and demand that the analyst show the reasoning why alternatives have not been chosen over the final story.

6. **Have all opposing reasons been weighed?**

The sixth question looks into the reasoning used during the creation of the presented story. Is all the reasoning done during the creation of the story clear and clearly documented? This has to be done for the supporting as well as the opposing reasons. The opposing reasons have to be weighed against the supporting reasons and for the most likely events the opposing reasons have to weigh in less than the supporting reasons.

Have all considerations that are used to weigh opposing reasons been made explicit? Has this been done both at the level of individual facts and events and at the level of stories as a whole?

This sub question is made in order to demand a clear reasoning is given. The analyst has to show how they came to the final story and which arguments they used and why. The analyst also needs to show the opposing reasons in order to show that he has taken them into account but that the final story defeats these opposing arguments.

2.4 Theories in use by the police

The following section introduces the theories that are applied by the Dutch police force. The theories were found in the book "het recherche portret" [2]and the paper by Heuer [13]. This section will give an answer to sub question 1.2

2.4.1 Devil's advocacy

This technique can be used to defend less likely scenarios and to try to see scenarios from a different perspective. This technique demands from analysts to take the role of someone opposing the most likely scenarios. They are forced to try to attack these scenarios in order to see if they can find any flaws in their

own reasoning. As mentioned by Heuer [13] the task of a tactical analyst is partially to play the role of the devil's advocate. He has to ask critical questions for each scenario that is created but he also has to create scenarios which are not very obvious but cannot be simply excluded.

2.4.2 Mind maps

The police uses mind maps to create different scenarios. They also use the mind map to put the different pros and cons of scenarios behind each possible scenario. The police mind map for a possible murder is always structured in a same manner. They start with four possibilities: "murder, accident, suicide and natural death" for each of these scenarios they give pros and cons. After giving pros and cons the police decides which scenario(s) to pursuit. For each of the scenarios the police fills in the 7w's. The 7w's are: who, what, where, with what, which way, when, why.

2.4.3 Network analysis

A network analysis can be done on the victim. The police often refers to network analysis as relation schemes. By building his or her social network it is possible to see in which milieus the victim lives and who potential suspects or witnesses are. The police uses this technique in in their investigations. Figure 7 shows an example for a network analysis for Nadia. Nadia is a student and lives in a student house, she is also a member of a student association. All these activities (squares) lead to potential witnesses and suspects (ovals). This analysis gives the police potential leads who to question and investigate.
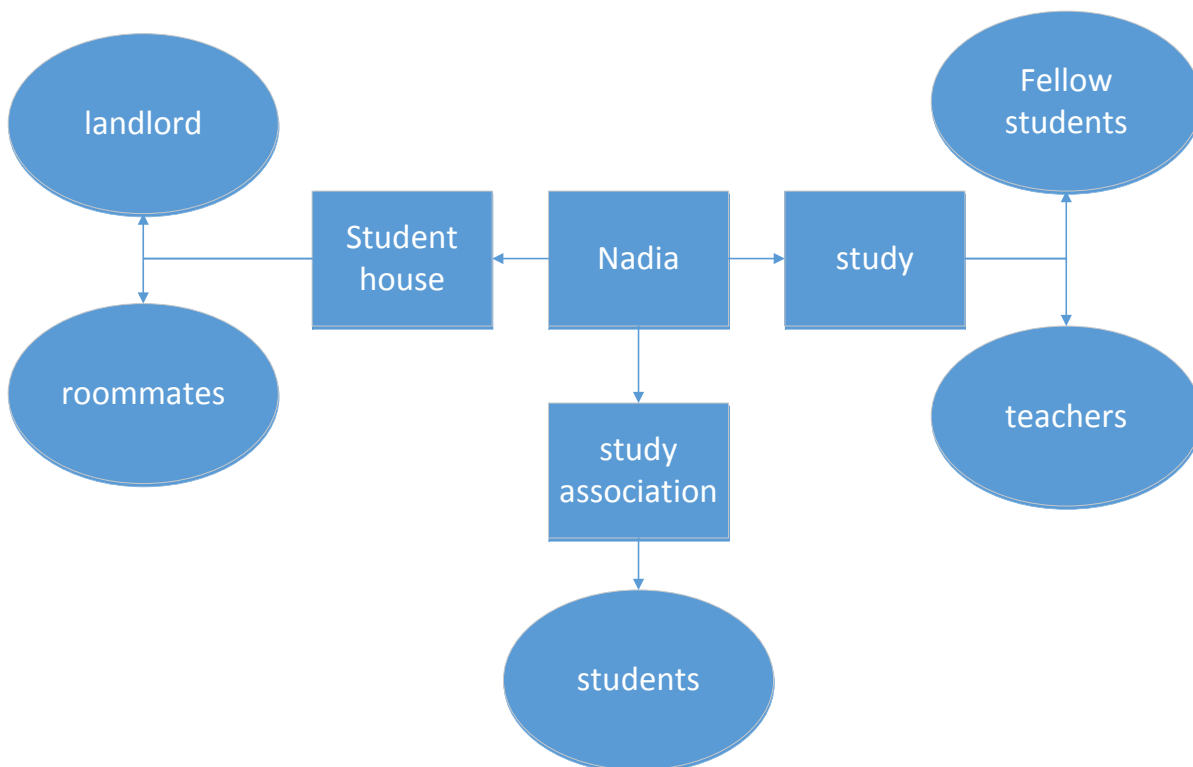

Figure 7: example of network diagram

2.4.4 Analysis of competing hypotheses

Making scenarios or stories out of evidence is not easy and many errors can be made. This subject has been studied by many researchers. Heuer [13] is one of the researchers who looked into this subject and he has written a book about creating scenarios which is used by the CIA. In this book he describes the strategies that analysts use when handling evidence and create scenarios. The following strategies are discussed:

- Situational logic focusses on cause- effect relationship. This means that the analyst starts with the known facts of the current situation. He seeks to identify the logical consequences of the given situation. In the case of Nadia's murder, the analyst tries to understand the current situation. The analyst tries to think how Nadia could be shot, why and by who. The logical consequence from the landlord shooting Nadia could be that the landlord has gun residue on his skin.
- Applying theory. By identifying certain conditions of a problem an analyst can use theories to predict what is going to happen or deduct what has happened. The analysts uses known theories to apply on the situation in order to try to understand what has happened. In the Nadia case the analyst could use theories the trajectory of shots to identify where the shooter stood. This might help with identifying the shooter.
- Comparison with historical situations. The analyst uses historical events to see if the new events are comparable. If the new events are comparable, the analyst can use the historic situations to help him understand what has happened. For example, there might be murders like the murder on Nadia. The analyst can use these historical cases and might learn where to search or how to find the perpetrator from these cases.
- Data immersion. The analyst immerses himself in data. The idea is that eventually a pattern of explanation will emerge from the data. Analyst would only be guided by the data and nothing else. This would mean for the Nadia case that the analyst only uses the data found at the crime scene to identify what has happened. This is done without bias from other cases.

Besides strategies Heuer describes potential solutions and strategies or aides to help overcome potential biasing when creating scenarios. These consist of the following strategies.

- Thinking backwards, the analysts starts with the assumption that an event happened which he did not expect. Then he places himself in the future and looks back at how this could have happened and what events had to occur in order to make the event happen. For example when a murder took place the analyst could go back in time to see what had to happen in order for the victim to get murdered.
- Crystal ball is almost the same as the previous technique. The idea is that some all-knowing creature tells the came up scenario is wrong and the analyst has to give this creature an explanation why the came up scenario is plausible. In this technique the analyst should have to convince the "creature" the scenario he created is the only one possible and there are no other possibilities. If he is able to do this, he will be sure that he has the best scenario.
- Role-playing is a common strategy to help analysts keep an open mind. The idea is that analysts take on a different role to see the problem from a different perspective. In this technique the analyst could take the place of the murderer and try to think like him. Why would I kill the victim? How would I do that and why would I do that? Are questions he might be able to answer if he steps into the role of the perpetrator.

The described strategies are designed to keep the mind of the analyst open and help him see information from different perspectives. Next to strategies used to be less biased Heuer also proposes a structure for analytical problems. He calls this strategy "analysis of competing hypotheses" further referred as ACH. ACH consists of the following eight steps:

1. Identify the possible hypotheses to be considered
2. Make a list of significant evidence and arguments for and against each hypotheses
3. Prepare a matrix with hypotheses across the top and evidence down the side
4. Refine the matrix
5. Draw tentative conclusions about the relative likelihood of each hypotheses
6. Analyze how sensitive the conclusion is to a few critical items of evidence
7. Report conclusion
8. Identify milestones for future observation

In the Nadia case the ACH would be executed as follows:
1. To keep things simple, we say that there are two scenarios. H1 the landlord killed Nadia with a gun or H2 Someone else killed Nadia with a gun.
2. For H1 the significant evidence would be that the landlord had anger issues, which is proved by a psychiatrist report, and when he was arrested he had gun residue on his hand. For H2 we could say that the generalization that people do not kill anyone for an argument over a washing machine.
3. The matrix would be as follows. + means positive for the hypothesis, "- "means against the hypothesis.

	H1	H2
Psychiatrist report	+	-
Gun residue	+	-

4. Since this is an easy case, no refining is needed.
5. Looking at the matrix the conclusion is that the evidence against hypothesis 2 is the strongest. The idea is that falsification is more important than conformation.
6. The gun residue is a very strong piece of evidence since most people do not just have gun residue on their hands. Therefore, it is possible to say that this is critical item of evidence.
7. The conclusion is that H1 is most likely the hypothesis the closest to the truth.
8. Not applicable for now.

2.5 Comparison

For the comparison of methods, the emphasis lies on comparing the hybrid theory to the analysis of competing hypotheses. This comparison is made because the analysis of competing hypotheses is one of the main methods used by the police today as one of their main theories on reasoning with evidence.

Both methods have a similar goal, they both want to determine the best scenario based on the evidence at hand although ACH focusses more on falsification of scenarios and the hybrid theory more on the support and the falsification of scenarios. This is most obvious when the matrix of ACH is shown, both "+" for support and "−"for attack can be filled in, but in the end the scenarios with the fewest pieces of evidence

supporting it are discarded. In the hybrid theory the aim of using arguments is to argument that events or series of events are possible and true. But the argumentation is also used to attack other arguments or events. So the both the supporting and attacking aspect get attention in the hybrid theory and the ACH focusses mainly on attacking stories.

Both the hybrid theory and the analysis of competing hypotheses work with arguments which can support a story or attack a story. Both methods encourage the user to make multiple scenarios which can be compared to each other. Although the analysis of competing hypotheses and the hybrid theory have the same goal, finding the best scenario using arguments, there are many differences. The first difference is that looking at the description of both methods the analysis of competing hypotheses has a clear to follow plan which can be followed step by step. The hybrid theory does give examples of how to use the method in practice, but there is no clear plan which can be followed in practice, which makes the hybrid theory more labor intensive to use in a criminal investigation because first a plan has to be made on how to really use this method, this could be done once and then be documented for future use.

The second difference is the way arguments are used in both methods. In the analysis of competing hypotheses, a matrix is made in which all scenarios are placed on the columns and arguments (or pieces of evidence) are placed on the rows. Then for each argument there is determined whether they contribute positive to the story (support) or attack the story (attack) or are neutral towards the story. This is often noted by a "+" for positive, a "– "or nothing or "0" for neutral

The hybrid theory does not necessarily use a matrix in order to compare scenarios to each other. Instead it plays out scenarios one by one. This is done by comparing scenarios one by one and playing them out against each other or by attacking arguments with other arguments in order to make the story weaker. The hybrid theory does not have a method in place to compare multiple stories at once. The arguments in the hybrid theory can be more complex as those used in the ACH. In ACH the argument is usually a statement or a single fact deducted from evidence. While in the hybrid theory an argument can be a whole reasoning using multiple facts or statements. The arguments in the hybrid theory can be more complex than those in the ACH.

A third very important difference is that the matrix form of the analysis of competing hypotheses does not allow arguments to mutually attack or defend. This means that pieces of arguments cannot attack or support each other. This is possible in the hybrid theory, as shown in figure 8 and 9.
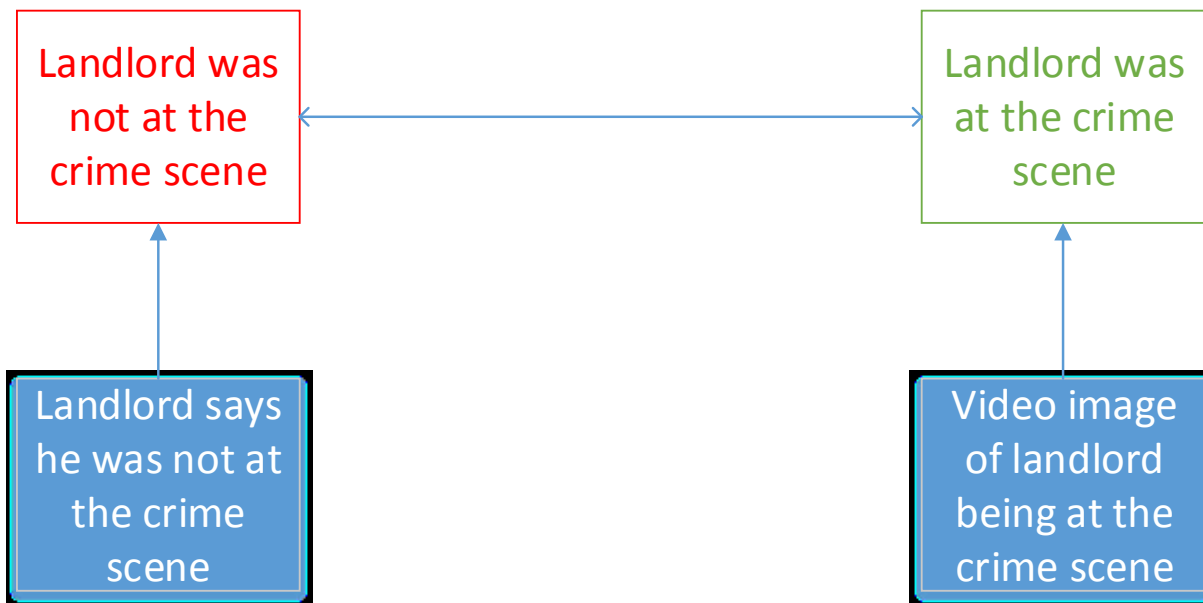
Figure 8: attack on the application of the evidence

As seen in figure 8 and 9 there are two ways of attacking arguments. The first way is attacking the application of an argument. In the example shown in figure 8 the conclusion "Landlord was not at the crime scene." Is supported by the evidence that "Land lords says he was not at the crime scene". This argument is contradicted by the argument that there is a video image of the landlord being at the crime scene. This argument leads to the conclusion "landlord was at the crime scene". These 2 conclusions contradict each other
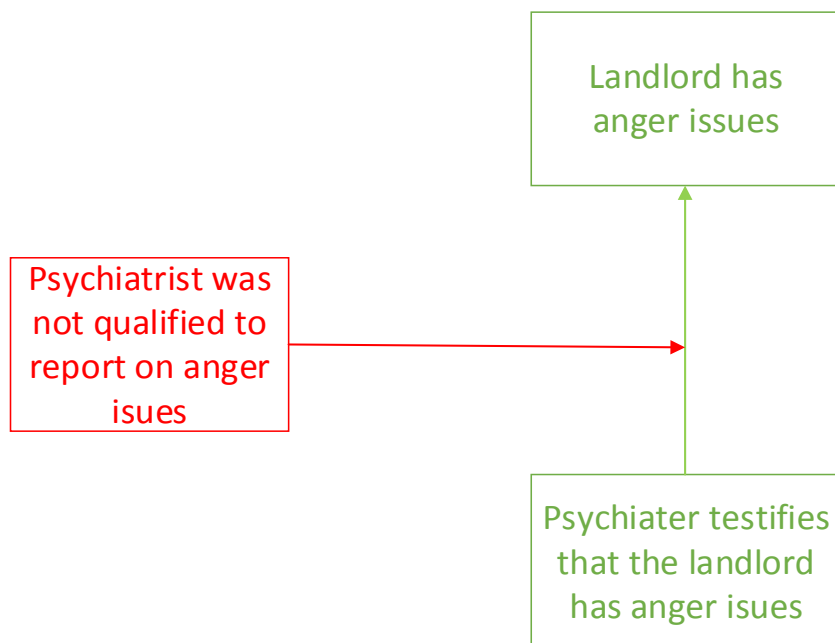
Figure 9: direct attack on the evidence

The second way of attacking is undercutting which means an attack on the inference from argument to the conclusion. In the example seen in figure 9 the argument "psychiatrist reports that landlord has anger issues" is undercut by the argument "psychiatrist was not qualified to report anger issues" this would mean that the whole argument is invalid now.

2.6 The hybrid theory method 0.1

The hybrid theory method is based on the steps taken in chapter six of the Arguments, Stories and Criminal Evidence, A Formal Hybrid Theory [1]. Although Bex does not describe these steps explicitly, it is possible to deduce steps from the example he describes. The method is created in order to keep it as close to the hybrid theory as possible. As mentioned before this method starts after the evidence has been collected from the crime scene.

1. Data extraction from the evidence at hand. This data extraction will be done in the same way the police extracts data now. This will be done using a chronolist. To refer to Pirolli and Card [3] the data extraction step is comparable with step five "read & extract", as seen in figure 2, where the information useful to the investigation is filtered out of the data.
2. Identify the victim. One of the first things to do is to understand who the victim is. What is his or her name, age, nicknames, social milieu, nationality and gender.
3. List suspects or groups of suspects. A first list of all the possible suspects is made. Facts like the name, age, gender, link to the suspect and possible motives are written down.
4. Define location of the crime scene (if not known from the beginning). Describe the location where the body is found to identify possible flight routes and cameras which could be useful for the investigation. If the body has been moved, the real murder scene has to be found as well.
5. Organize evidence (by date, person, source)
6. Start with describing cause of death, murder weapon based on evidence (can be broad and be specified later). For example, start with blunt object later specified to hammer). This can already result in different stories (different weapons, different causes of death).
7. Use story schemes for the committed crime to create the first stories. (Can be done based on x-mind scheme combined with other story schemes for crime). These story schemes will be the basis to build real stories in step eight. They will also give a quick oversight of what is missing to create a story.
8. Make a story about the crime committed. This is equal to step thirteen of Pirolli and Card "hypotheses" and step fourteen "tell story" these steps create stories from the found data.
9. Identify the final story.
   a. Make different stories about the crime filling in different persons or groups of persons. This is equal to Pirolli and Card's step eleven "build case" where multiple scenarios are made. Here critical question one "Are the facts of the case made sufficiently explicit in a story?" comes in. This question asks the analyst to look critically at the created stories to see if the facts are made explicit.
   b. Support each story with evidence and generalizations.
      This step is supported by the second critical question "Is the story sufficiently supported by evidence?" This is where critical step three "Is the support that the evidence gives to the story sufficiently relevant and strong?" comes into play. This question demands that the analyst looks critically at his given arguments and look if they are relevant for the story and if they are strong enough to survive attackting.
   c. Try to fill evidential gaps
   d. Try to attack each story with evidence and generalizations. Equal to step fifteen "reevaluate" of Pirolli and Card [3] where the different stories are reevaluated to find the best one(s).

This is where critical questions four "Has the story itself been sufficiently critically assessed?" five" Have alternative stories been sufficiently taken into account?" and six "Have all opposing reasons been weighed?" come into play. These questions help to improve the attacking of stories and arguments by asking if all the opposing arguments and stories have been found. If these opposing stories and arguments have not all been found, then the "best" story might still be wrong. This is because if for example an opposing argument for the "best" story is found which renders that story false, then this story is no longer the best. This can only be done when all opposing arguments for that story have been found.

e.   Keep the best story.
The best story should be the one which has the strongest arguments supporting it and which ideally does not have too many evidential gaps. This story should still be examined critically using all the six critical questions.

3 Case study part one

This chapter describes the case study which has been performed in this research. First the police practice is explained. Section 3.1 explains how the police works in practice by giving a practical example. Section 3.2 to 3.12 of this chapter are dedicated to the case study performed at the Dutch police force. These sections of this chapter explain each step of the hybrid theory method and explain the problems found when applying the hybrid theory method in practice and the solutions applied to make the hybrid solve the encountered problems. Section 3.13 with the improved hybrid theory method based on the case study. The case study will provide an answer to research question 2 and sub research question 2.2.

3.1 The police practice

The main task of the tactical analyst is to prevent tunnel vision and falsify scenarios. An Operational analyst makes a chronolist from all the evidence. This is a list of important information from evidence ordered in chronological order. The chronolist is used to see which information is available about who and who has given this information. A chronolist has the following information: "date and time 1, date and time 2, stated by, stated about, content, source, page, note" This chronolist is the basis of the investigation and the basis of the mind map.

The mind map is used to show the different possible scenarios. A mind map always starts with four different hypotheses: "natural death, suicide, accident, murder". Each of these hypotheses is filled in with the arguments using the 7 w's. The 7w's are:

1. Wie (who)
2. Wat (what)
3. Waar (where) -> crime
4. Waarmee (with what) -> means
5. Welke wijze (which way)
6. Wanneer (when)
7. Waarom (why)

These 7 w's are the basis for each hypothesis the police uses in their investigation, so each hypothesis should contain each of the 7w's. The goal of the analyst is to falsify hypotheses. He tries to prove that hypotheses are not possible and to think of alternatives which could have happened. With each of the 7W's filled in the analysts asks questions. These questions have to be investigated by a group of officers leading the police investigations. The tactical analyst asks for information to falsify his scenarios. These questions are translated to practical questions. These questions are given to the officers leading the investigations. These officers send detectives to find this information. The questions are gathered in an informatie collectie plan (ICP or information collection plan in English.) this is a list of all the questions the tactical analyst needs answered in order to prove or falsify a scenario.

In the mind map the term NN (Nomen Nescio) is used when the name of the suspect(s) is not known. There could be multiple NN's, which can be indicated by numbers or by the description of the NN coming from the evidence.

3.1.1 Example housewife murder

To show how the police works in practice and which steps they take to find all the possible scenarios for a crime a small example is presented in this section. For this example the murder of a woman is used. This was a real case solved which was explained by the police for this research in order to explain how the solving of a crime works in practice. This woman is found dead in her house with multiple stab wounds. At the time of the murder her ex-husband and her children were in the house. The woman was murdered in the kitchen but was moved to the garage.

   The first step the operational analyst takes is to create a chronolist. This chronolist is filled using the evidence of this case. In this simplified case the evidence exists of the police report of the crime scene, the hearings of the children, a report of the coroner and a hearing of the neighbor as can be seen in figure 10. Furthermore, there is a restraining order against the ex-husband coming from the housewife. From each of these pieces of evidence the most important statements are taken and put into the chronolist.

date 1	time	date 2	time	stated by	stated about	content	source
1-1-2016	15:00			Youngest child	mother (victim)	112 call in which the youngest child calls 112 to report her mother is murderd	112 call register
				police	ex-husband	ex-husband has a restraining order from seeing the mother	police report
				neigbour	ex-husband	the ex came by the hose often	questioning of the neighbour
	14:30			neigbour	ex-husband	the ex drove away around 14:30	questioning of the neighbour
1-1-2016	13:30			oldest child	ex-husband	ex-husband came to the house around 13:30	questioning of the oldest child
1-1-2016	13:00	1-1-2016	15:00	oldest child		the children were playing upstairs and did not hear anything	questioning of the oldest child
				police	mother (victim)	killed with 10 stabs	police report of the coroner on site
				police	mother (victim)	body was dragged from the kitchen to the garage	police report of the coroner on site
				Youngest child	mother (victim)	mother and ex have been arguing a lot lately	questioning of the youngest child

Figure 10: A chronolist

After the chronolist is set-up a mind map is made by the tactical analyst in which the potential scenarios are placed. Both the mind map and the chronolist will be altered continuously during the investigation. These scenarios are in the mind map supported or opposed by data coming from the chronolist.

   This mind map is divided in four potential abstract hypotheses. The first one is natural death, as can be seen in figure 11. This hypothesis is falsified by the evidence coming from the NFI that the housewife died of stabbing.
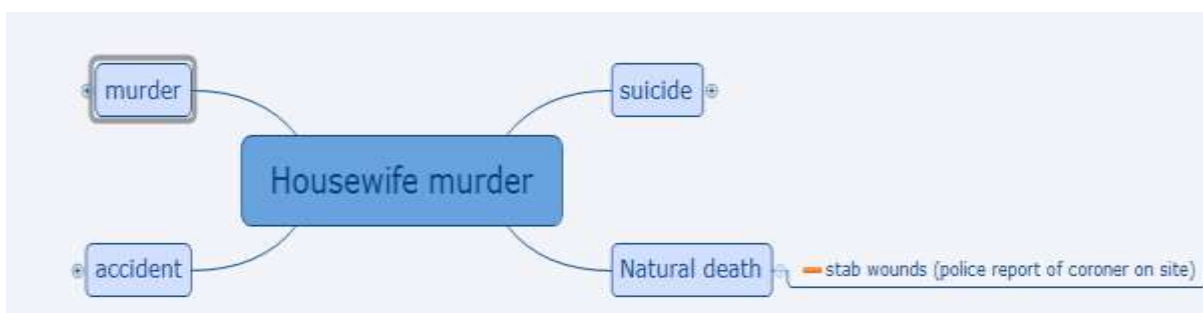
Figure 11: natural death scenario in mind map

The second hypothesis is that the housewife committed suicide and is shown in figure 12. This hypothesis can also be falsified using the report of the NFI saying that this number of stab wounds is not possible to inflict on yourself, the body also seems to be moved which indicates that at least someone else should have moved the body.

Figure 12: the suicide scenario

The third hypothesis is "an accident". This hypothesis is shown in figure 13. This hypothesis is, just like hypotheses one and two, not likely since the housewife has died of multiple stab wounds which is possible with an accident but not this many (report of the NFI).

Figure 13: the accident scenario

The fourth hypothesis is murder and is shown in figure 14. This is the most likely hypothesis of the four hypotheses. Therefore the most effort will be put in this hypothesis. In this case the other hypotheses can be discarded. However, in the case that they cannot be discarded every possible hypothesis has to be investigated until they can be completely falsified. This next step is to fill in the 7W's. Again in this case they are only filled in for murder, but when it is less obvious which scenario it is this will be done for multiple scenarios.

Figure 14: the murder scenarios with W's

As can be seen in figure 15 not all the W's are mentioned separately from the beginning. For example, the "why" will be placed after the "who" to connect the motives with the persons. The set-up of the mind map

and the division of the w's over the mind map is done differently by each analyst. The next step is to fill in as much as possible for the W's. In this case it is possible to start with filling in the where, which way and with.
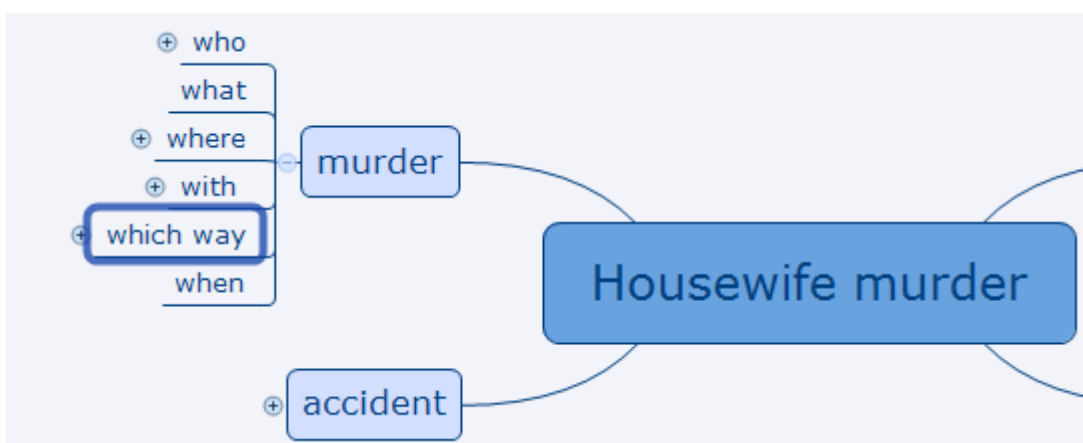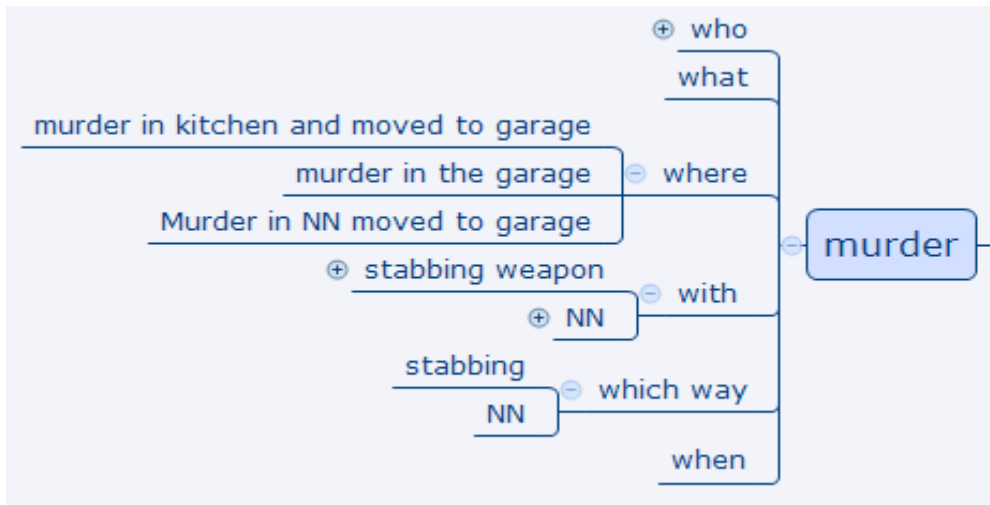

Figure 15: filling in of the were, wit hand which way

For each of the W's there are multiple options which are kept open until falsified. First the where is discussed as seen in figure 16. There are three options of what could have happened. Since the body is found in the garage it is certain that it ended up in there. So this gives the scenario that the housewife was murdered in the garage. However, the coroner's report mentions that the body was moved so the murder took place somewhere else (indicated with a -). The second possibility is that the murder took place in the kitchen and the body was moved from the kitchen to the garage. This is supported by the coroner's report that blood was also found in the kitchen (indicated with a +). The last scenario is that the housewife was murdered somewhere else and then moved to the garage. This scenario cannot be falsified since we do not have enough information to falsify. This means that the analyst will place a question mark together with the request for information (indicated with?). He specifies which information he needs in order to falsify this scenario. All these requests for information will be put in an ICP. In this case the analyst wants to know if there are bloodstains outside of the kitchen and garage. If the result of this question is "no" he can falsify this scenario.
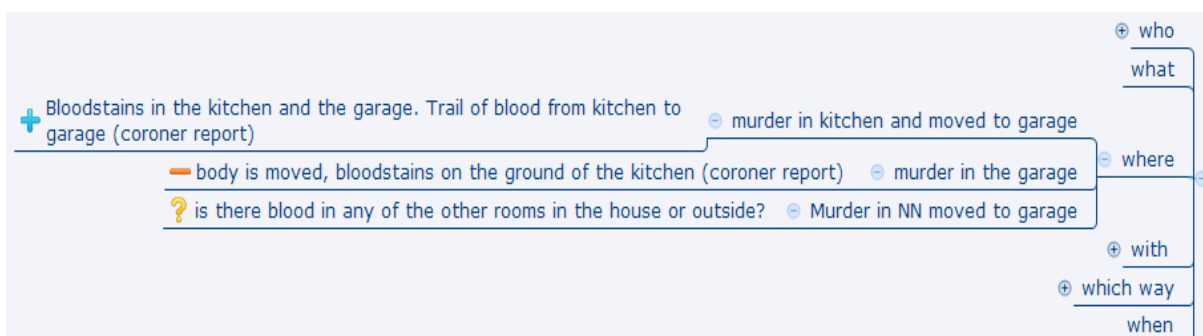
Figure 16: where with evidence and arguments.

The "with" and "which way" are closely connected. This is due the fact that the weapon influences the way the murder is performed. As done for the "where" the pros and cons are listed after the possible scenarios. This leads to the conclusion that it is likely that the murder has happened with the kitchen knife found in the kitchen. This can be seen in figure 17.

Figure 17: with and which way

The same can be done for the "when" as seen in figure 18.

This leaves 3 W's to be explained. The "who, what and why". The "what" is often the last W to be filled in because this sums up what has happened. The "who" and "why" are in this case closely connected so they are put together. This is because the perpetrator influences the reason why and vice versa. This arranging and coupling of W's can change per case and analyst. For the "who" we have a few possible suspects as seen in figure 19.
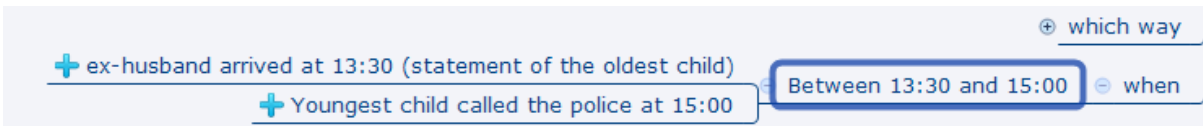
Figure 18: when

Figure 19: Who

First the oldest and middle child are discussed. Both were in the house when the murder happened. However, the only argument that could be found for them to kill their mother would be an argument. None of the children had real arguments with their mother and all of the children were genuine shocked when the police arrived. These arguments are shown in figure 20.
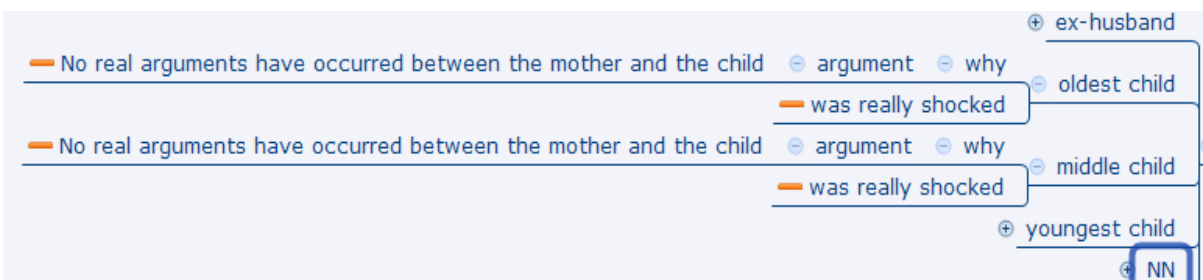
Figure 20: oldest or middle child alone

The next possible murders could be the youngest child and the NN. The youngest child found the mother first and called 112. However, she is too small and weak to have carried out this attack alone. This leads to two possible scenarios. One is that the children murdered their mother together and two is that someone came from the outside and murdered the housewife. This last scenario is called the NN scenario. Both the NN and the children scenario are falsified. The children still do not have a motive and were all really shocked. For the NN coming from the outside the analyst asks the question if all the doors and windows were locked and if there were signs of breaking in. This was not the case so this person could not have come into the house, falsifying this scenario. This is all seen in figure 21.
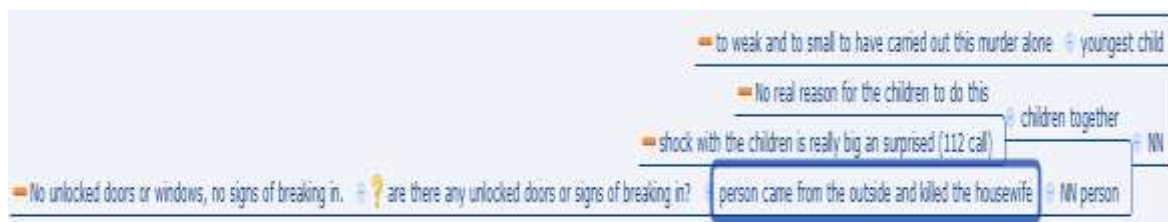
Figure 21: youngest child or NN

So this leaves the Ex-husband. He has a history of violence and blood of the housewife was found on his clothes. He was in the house at the time of the murder. For motives there are also some possibilities. He was jealous because the housewife (his ex-wife) was going to live together with a new boyfriend, he had a restraining order against him but still kept visiting and he argued a lot with the housewife. These arguments are shown in figure 22.

Figure 22: the ex-husband

These pieces of evidence together, with the exception of motive, with the falsifying of all the different scenarios leads to the "what" as seen in figure 23.
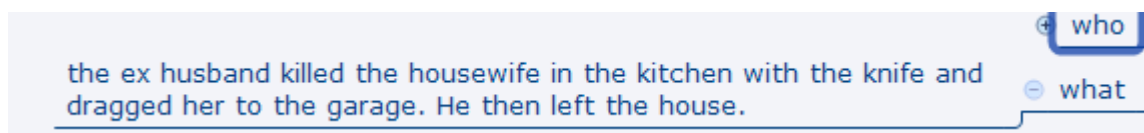
Figure 23: what

After the mind map is completely filled the analyst sums the mind map up in a report for the prosecutor. They will decide if the case is strong enough to take to court or if they want more evidence. The results in the report will always be presented as "this is the most likely scenario". The other scenarios will also be presented but with the mention that they are not very likely and the reasons why. The analyst will never state that this is definitely what has happened. This is done to keep the prosecutor from receiving tunnel vision and not looking beyond the presented most likely scenario.

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All the possible scenarios and possibilities are created from evidence found at the crime scene and the experience and critical thinking of the analyst. This means that detectives are dependent on their analyst to think outside the box to think of scenarios that can also be possible. The end goal is to falsify every possible scenario until one or none remains. None is also a possibility because it is not because one scenario is left that the analyst just assumes that this is the one. He still tries to falsify it in order to be sure that this is the real scenario. In court the prosecution wants to be able to falsify every possible scenario the defense can come up with.

The following section describes the case study that has been carried out during the graduation project. The section will describe each step taken in the case study in three ways. First the aim of the hybrid theory method step is described. After explaining the aim the problems and solutions encountered in practice are described and finally the chosen practical solution is described with an explanation of why this is this right solution. This chosen solution is also the step which is used for the hybrid theory 1.0 method. The hybrid theory 1.0 method is the improved version of the theoretical hybrid theory 0.1 method.

3.2 The case study case

In the next section of this chapter the case study will be described. First the case which has been handled in the case study will be described. After this short introduction to the case a description is given about how the hybrid theory method was executed in practice. For each step of the hybrid theory method the theoretical step is given, then the problems which occurred during the execution of the hybrid theory method in practice are described together with the solutions which were applied. In the end the improved step of the hybrid theory method is described.

Early one morning a jogger found a body in a park. He called the police who responded to the site immediately. The police finds a man lying on the ground in the park. Investigation shows that he is shot multiple times. The victim is Tim. Tim is a drug addict known to the police for several small crimes. He often hangs out in the park. Most of his friends are drugs users as well. These drug addicts gather in the park to use drugs, they also obtain drugs from a regulated drug distribution. The body of the victim had not been moved since he was shot and bullets are found in the ground indicating that the murder has happened at the place they body lied when the police arrived. The park were Tim is shot is known to be a gathering place for junkies and homosexuals at night. After the body s found the police start an investigation. They question the people living around the park. Since there is no direct suspect a TGO (team grootschalig onderzoek or Team big scale investigation) is created. The analysts of the police investigate the evidence.

The names and places mentioned in this thesis are made up in order to keep the case anonymous. The case itself was a real murder case which was already solved in the past. The evidence used in the case study was the real evidence made available by the Dutch police force.

For this case study the Dutch police force made the evidence for this case available. The evidence was divided into two parts. One part represented approximately the first three weeks of the investigation. The second part represented the evidence found after the three weeks. This three-week point was a tipping point in the investigation.

3.3 Data extraction from the evidence at hand

3.3.1 Description

The main goal of the first step of the hybrid theory method is to collect and organize the evidence of the case. Since the hybrid theory does not describe any evidence collection methods the police theory and

practice was used. In the police theory a chronolist was proposed in order to collect and organize all statements coming from the evidence. The chronolist is also used by the police analysts in practice to organize the evidence. Since the first step is the basis for all the following steps in the method, it needs to contain all the statements. The statements coming from the evidence in the case will form the arguments used in the next steps of the method.

3.3.2 Practice

In the case study statements were taken from the evidence coming from the case. The evidence consisted of a selection of statements, police reports and reports of phone taps and observations.
The statements taken from this evidence ranged from neighbors stating they heard noises on the night of the murder to people stating the victim had a fight with drug dealers. The result in the case study was a chronolist with around 200 statements.

Problems

The first problem is not a problem of the hybrid theory but is a problem with the theoretical solution for the problem that the hybrid theory does not mention how to collect the information of an investigation. To solve this problem the creation of a chronolist was suggested by the police theory. When building a chronolist in practice some problems might occur. One of the problems found in the case study was that if a piece of evidence contains multiple (conflicting) statements it was hard to refer to these statements using the original chronolist. For example if the police collect statements from people living in the neighborhood of the crime scene, they collect this all in one document. To use each statement it is easy to be able to refer to the rules of that statement

Solutions

To cope with multiple statements and conflicting statements in the same piece of evidence the reference in the chronolist was altered. Instead of just referring to the piece of evidence and the page which the statement was taken from, the line numbers from the original text were also written down as seen in figure 24. This made it possible to easily use all the statements coming from one piece of evidence.

Verhoor van de getuige Neighbor 21 P2 R53- P3 R46

Verhoor van de getuige Nadia P2 R14-16

Verhoor van de getuige Nadia P2 R24-27 P3 R23-24
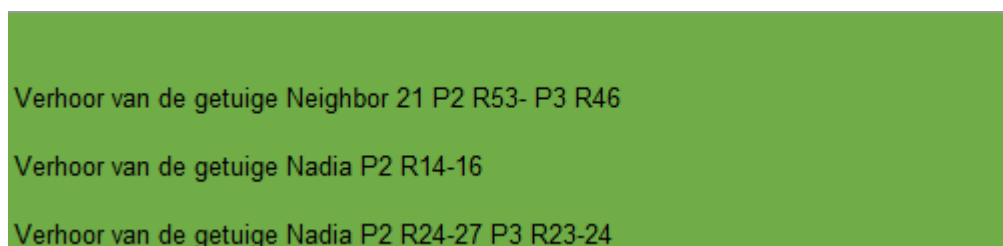
Figure 24: example of the references in the chronolist. P stands for page and R stands for rule

Extra

The chronolist was made by an unexperienced person. This could have led to missing information or data when gathering information from the evidence. To counter this problem the chronolist created for the case study was checked by analysts, who concluded that no vital information was missing from the chronolist.

3.3.3 Hybrid theory 1.0 step

Learning from the problem from the case study, the chronolist was altered to include the rule numbers of the statements.

3.4 Identify the victim

3.4.1 Description

The second step of the hybrid theory method explains who the victim of the crime is. It is important to know as much as possible about the victim: this will give an insight in the victim's life in order to find potential perpetrators.

3.4.2 Practice

In practice this step is usually not difficult to execute. The victim can be identified using personal documents found on the victim or his family or friends can identify the victim. There are examples where the victim is so badly mutilated that identification could be difficult. In these cases DNA or other forensic methods are used to identify the victim. The summary of the victim will contain his name, age, nickname(s), address, nationality, family and criminal record.

In the case study the body was found with his wallet on him. This made identification easy. The victim was a drug addict was known to the police. The victim had multiple convictions for small crimes like theft.

Problems

This step was not elaborate during the case study since the victim was found with his personal belongings on him. His wallet was found with his identity card. This meant that there was no need for argumentation who the victim is.

Solutions

Since there were no problems in this step, there was no need for solutions.

3.4.3 Hybrid theory 1.0 step

The executed step two was collecting the following data about the victim: name, age, nickname, address, nationality, family and criminal record. For all the information that was added to this summary, a source from the chronolist had to be added in order to be able to check the information for truth. The result of step two in the hybrid theory method is shown in figure 25.

What		Source
Victim name	Tim (victim)	informatierapport
Nickname		informatierapport
Age		informatierapport
Adress	Lives with Pim	informatierapport
Nationality		informatierapport
Family	Father , Mother, sister, two children and (ex-) wife	informatierapport and statement of Bert
Criminal record	Drug addict, Theft, robery with violence	informatierapport
Social milieu	hangs around in the park	Multiple statements

Figure 25: example of victim identification with sources

3.5 Identify the suspects

3.5.1 Description

Step three is one of the most important steps of the hybrid theory method. In this step all the suspects are described. It is important to take all the potential suspects into account in order to keep the stories in later steps unbiased. If not all the suspects are found or mentioned then the real perpetrator can be missed. Not mentioning all the suspects can also lead to bias, which could lead to errors in the investigation.

3.5.2 Practice

According to the police identifying the suspects is one of the most difficult steps in an investigation. Finding the suspects usually gives focus to the investigation. When a clear suspect is found the police is often close to closing the investigation, because focus can be laid on one person and his potential motive. In most of the investigations, the motive and perpetrator are the last things to be found. Because this step is such an important and difficult step, the choice was made to divide the step into 4 sub steps. The first sub step made in step three of the hybrid theory method is the listing of all the people who play a role in the investigation. This is done in order not to miss potential suspects.

In examples from the literature where the hybrid theory is explained there are never more than four suspects. This makes it possible to reason about each individual. In practice there are often more than 60 people who play a role in an investigation. Reasoning about them individually is impossible. Therefore roles are proposed. Roles enable the police to reason about groups of people instead of each person alone. In practice the giving of roles will be sub step two and the reasoning about the roles will be sub step three. The application of roles within this case study leads to the first problem "giving people a role might cause bias". This problem is discussed below.

Sub step two gives each individual a role; this allows to reason about whole groups of people instead of each individual on its own. For this case study each person only received one role. After giving each individual a role, the reasoning about roles begins. This is sub step 3, where per role the link to the victim and potential motives for the crime are given. All these motives have to be supported with arguments. When the motives and arguments are filled for each role, the decision has to be made which role is suspicious and which roles are not. The people who have a suspicious role are taken to the next sub step, where their names are stated together with their age, gender, link to the victim and motives. The people who are left in the last sub step will be used later to create stories.

In the case study around 60 people were listed in the people list. Most people had one of three roles: neighbor, friend from the drug scene and friend from the gay scene. There were several people with unique roles. This means that they were the only person with that role. One of these unique roles was the role of victim of the victim. The victim was known to rob people in the park and one person came forward with the fact that the victim robbed him. Using the motives from the chronolist a few roles proved to be suspicious with high priority. Examples of these high priority suspicious roles where: "the man who was robbed by the victim, all his friends from the drugs scene and some drug dealers. These people were all described one by one in the last step of identifying the suspects and for each person potential motives were described.

Problems

1. Giving people a role leads to the next problem: giving people a role might cause bias. Giving a person a certain role will determine later if he or she is a suspect or not. Giving a person a person a wrong

role can cause him or her to become less obvious in the investigation. If ,for example, Adam would get the same role as the group of people who visit the park at night, he might not have popped out as a suspect.

2. There are no clear criteria for determining if a role is suspect or not. Per investigation each role has to be determined. Using the evidence available in each investigation the suspicion of each role can be determined. This will vary per case. In the case study the neighbors of the park a not suspect. In another case the neighbors could be suspect. This all depend on the evidence and the case at hand.

3. Lot of suspects remain when using the division suspects or non-suspects. Excluding people from suspicion with certainty is very difficult to do. In the case study there were a lot of drug users involved in the case. All the people with the role drug user could have had a reason to kill the victim, but they all never killed or attacked anyone so they were not violent. This made them all not very suspicious but they still had to remain in sight.

Solutions

1. The proposed solution of giving people a role might always lead to error. However, people who are distinctly different from all the other people in the investigation will be given a different (unique) role. This will give the possibility to reason about people separately if needed. People with their roles can be seen in figure 26. In this case study each person only got one role. There were no persons who needed more than one role. If this were the case the most suspect role could be assigned to the person. For example if someone is a neighbor who lives next to the crime scene and also lives with the victim he will get the role of housemate of the victim instead of just a neighbor. This is because the role of housemate is more suspect then the role of neighbor. So to make the error as small as possible each person who diverts a bit from a role will get their own role. The colors in image 26 and 27 represent the priority of the suspects. Green means this role is not suspect. The orange color means this role is low priority suspect. Red means this is a high priority suspect.

Name	Role
Adam	Agressive homosexual, might have been robbed by Tim
Pim	Tim lives at Pim
Steven	friend of the victim (drugscene)
Saeed	Robs homosexuals in the park
Willem	friend of the victim (drugscene)
Renee	Friend of Adam
Zaccheus	dealer with Marokan nationality
Refugee 1	refugee, in the park when police arive at the crime scene
Neighbor 1	neighbor
Neighbor 2	neighbor

Figure 26: extract from the people list with their roles

2. If a role is suspicious or not can vary on a few factors. The main elements to look at are the potential motives for the crime and the link to the victim. The arguments or motives used in this step are manually deduced from the chronolist of step 1. This is done by using the evidence in the chronolist which is related to each person. The analyst will have to make the decision if a role is suspicious or not. However, if a role is not suspicious then the people who have that role will still be included in the investigation. This is done because information can change and this could lead to changes in the role. Examples of non-suspicious, suspicious low priority and suspicious high priority can be seen in figures 27 and 28.

Role	neighbor	Agressive homosexual, might have been robbed by Tim	Tim is housemate Pim
link to the victim	None	might have been robbed by the victim	Victim lives with this man
motives	None	revenge	fight about living arangements
		fight to get his stuff back	fight about drugs
			fight about money
arguments for motive	No motives	is known to be aggressive	Got into arguments
			drugsusers
arguments for link	dont know the victim	might have been robbed by the victim	lives with the vicitim

Figure 27: extraction from the roles argumentation with a non-suspect, high priority suspect and low priority suspect

3. The problem that many people remain suspect after step 3 is a problem that the police encounters a lot in their daily practice. Therefore, they divide the suspicious people into high and low priority suspects. This gives them room to not directly exclude persons from being a suspect but still keep them in the picture of the investigators. The police gives high priority to suspects who have a good motive. Not only the motive counts for the police but also the amount of information available to the police matters in the decision of making someone a high or low priority suspect. The main purpose of the roles together with the priorities is to exclude large groups of people with a non-suspect role from the investigation if possible and to focus the investigation on high priority suspects. The aim is to make advances in the investigation as fast as possible. In the case study ,for example, there are a lot of junks who are low priority suspects. By giving them a low priority suspect role these people are not excluded from the investigation but the focus can be given to other suspects with a higher priority. This step results in a summary as seen in figure 28.

3.5.3 Hybrid theory 1.0 step

Using the proposed solutions used in the case study, step three is built up in four sub steps in the hybrid theory method.

1. Make a list of all the people in the investigation
2. Give a role to each person in the investigation
3. Give for each role the link to the victim, the potential motives for the crime and the arguments supporting the link and motives. Using the link and motives the analyst determines if the role is no suspects, low priority suspect or high priority suspect.
4. After the prioritizing of each role, the investigator looks at the first list of persons and picks out each person with a high priority role. Using the information from the chronolist from step one each person who has the high priority suspect role is listed in the final sub step of step three. For each person left with a high profile suspect role the name, age, gender, link to the victim and motives are given. As seen in figure 28. This information is gathered manually.

Suspects		
Name	Adam	Renee
Age		
Gender	Male	male
link to the victim	was probably robbed by the victim earlier	
Motive	revenge	Revenge for stealing from his friend
	fight to get his stuff back	
	defense at third robbery	

Figure 28: the final suspects with age (censored for privacy), gender, link to victim and potential motives

3.6 Describe the crime scene

3.6.1 Description

The crime scene is inferred from the information of the chronolist. Knowing the crime scene can help identify potential witnesses and other information such as which cameras to watch. If the body is moved, it will be necessary to determine the initial crime scene and there has to be determined how the body moved to the place where it was found. It is important to describe the crime scene well. The crime scene can lead to potential suspects and witnesses. The crime scene also plays a role in determining how the crime has happened and how the victim and suspect have moved. If the crime scene is known, the potential getaway routes can be determined. This can help to interpret witness statements and can help to find potential evidence like camera along the potential getaway routes.

3.6.2 Practice

In the case study the crime scene is a public park. The park is known for the nightly gathering of drug addicts and homosexuals. The crime scene leads to many different groups of people that can be questioned for more information

Problems
In the case study the crime scene was easily determined. The body was still laying in the park where he was murdered. Talking with analysts reveals that most of the time the crime scene is easily determined. It is possible that there are multiple crime scenes, for example when a body is moved. Then more elaborate argumentation is needed about how the body is moved and/or how the suspects moved from one crime scene to another. In the case study this park is used at night by junkies and homosexuals. These two groups of people are potential witnesses or suspects.

Solutions
Since there were no problems in this step in the case study, no solutions were needed.

3.6.3 Hybrid theory 1.0 step

Step 4 in the hybrid theory method was executed as follows: give for the crime scene(s) the name of the crime scene, the location of the crime scene, a map of the crime scene and where the crime scene is known for. This last property is noted to determine which groups of people potentially were at the crime scene. The result of the step is shown in figure 29. This figure is however anonymized.

Name	Location	map		
Park	Park			
Known for				
nightly drugs users				
nightly gay meeting place				

Figure 29: example of the crime scene information

3.7 Organize the evidence

3.7.1 Description

The evidence used in the chronolist has to be ordered in order to use it later when arguing about different stories. Bex sorts the evidence in the example case of his book [1] in three categories: police reports (documents), expert reports (expert testimony) and witness reports (witness testimony). In each of these three categories Bex further divides the evidence into different crimes, which are related to the murder. This division is only used in one of his examples and was used as a basis for the division used in this case study. Bex does not propose this division as an official hybrid theory division of evidence.

3.7.2 Practice

In the case study around 200 statements were classified into one of the three main categories: "motive, means and opportunity". Most statements were about the motives and the possibility for the crime. A large majority of the statements were witness statements. A smaller portion were police statements and only a few expert statements were present. These expert statements were the reports of the NFI about the cause of death and the murder weapon.

Problems
1. Most investigated crimes do not have other crimes which can be linked to the investigated crime. Therefore this division of evidence per crime might not be useful in many cases. In the case study the victim is known to commit crimes, but these crimes are small and are not really reason to kill him.
2. A second problem is that not all statements can be placed under one of the three categories.

Solutions
1. A different division can be used to divide the evidence in the investigation. There are a few different possibilities to categorize the evidence:
- **Per crime/ event**

Just as Bex did in his example. The evidence can be divided per crime or event that is relevant to the murder. This can be useful when a lot of events or crimes might have led to the eventual murder.
- **Per argument**

Ordering evidence per argument might help the reasoning with arguments, since it allows the support of the argument using the evidence. This would take a lot of time because there are many arguments in an investigation.
- **Per social scene**

This could be useful in order to see which social scene might be interesting to find potential new witnesses or suspects. If there is a lot of evidence in one social scene this might indicate the victim was very active there.

- **Per person**

It is also possible to organize the evidence per person. This would however mean that there might be a lot of different organizations or a chaotic division. This raises the question, if there are 30 different divisions is it still workable? However, the evidence per person is already partially stated in the chronolist where statements about people are notated.

However, the starting point is the three main criteria for a person to commit a crime. The three criteria are: "the person has a motive, the person has the opportunity and the person has the means." These three criteria can be the base of division for evidence. This would mean that evidence about motive for the crime is placed under the "has a motive" category. The evidence about place and time of the crime and the suspect is placed und the "has opportunity" category and evidence about the weapon(s) and transportation from and to the crime scene is placed under the "has means" category. Underneath these categories the division proposed by Bex will be used where the evidence is divided in police reports, expert reports and witness reports.

In the "motive" category all the evidence regarding reasons to kill the victim is gathered. This can be statements about crimes the victim participated in or fights and other conflicts the victim was involved in.

In the "opportunity" category, statements about people being at the crime scene or other interesting location will be placed. These statements help defining who was where at which moment.

In the "has means" category statements about the murder weapon and possible escape vehicles. These statements help defining who had the means to kill the victim and the means to go to and from the murder scene. Statements about the (potential) murder weapon and who has access to these kind of weapons at the time of the murder.

2. Evidence that cannot be placed under a certain category has to be examined separately. Most of the time this is information for the proceedings of the investigation but not information for arguing about stories. An example of this kind of evidence is the mentioning of other people who could be questioned by a witness. Or if a witness gives information about the victim's family.

3.7.3 Hybrid theory 1.0 step

Using the police practice step 5 was executed in the following way. The evidence is divided into three categories: motive, means and opportunity. These 3 categories all have three sub categories. The subcategories are based on the categories from F. Bex. The sub categories are police report, expert report and witness report. The result of the motive part of this step is seen in figure 30.

has means
police report
PV sporenonderzoek PD P2 R48-52
PV sporenonderzoek PD P3 R14-R42
PV sporenonderzoek PD P4 R18 -P5 R27
PV sporenonderzoek PD P5 R51-54
PROCES-VERBAAL van Bevindingen identiteit Bram en Zaccheus P6 R39-41
PROCES-VERBAAL van Bevindingen identiteit Bram en Zaccheus P6 R41-42
PROCES-VERBAAL van Bevindingen identiteit Bram en Zaccheus P6 R56-57
PROCES-VERBAAL van Bevindingen identiteit Bram en Zaccheus P7 R7
Schriftelijke uitwerking verhoor Adam 20-08-2015 p11 r37-38
expert report
voorlopig sectierapport (geheel)
NFI rapport wapen en munitie (geheel)
witness report
Pv bevindingen getuige Achmed P1 R39-45
Verhoor van de getuige Alfred 26-07-2016 P2 R37-39
Verhoor van getuige WillemP4 R25-29
Proces verbaal van bevindingen m.b.t. verklaring Roel P3 R19-36
verhoor van de getuige Steven P2 R26-31
verhoor getuige LuukP4 R33-44

Figure 30: has means part of the evidence division.

3.8 Describe the cause of death and/ or the weapon used in the crime.

3.8.1 Description

Determining the weapon(s) used in the crime and the cause of death in a murder case is very important. The weapon can lead to the potential perpetrator. The cause of death can tell something about the perpetrator and about potential motives. Learning from the example cases of the police the murder weapon and cause of death is never very difficult to determine. For future cases this step can be place before step 5. The cause of death is mostly determined by the NFI (Nederlands Forensisch Instituut.).

3.8.2 Practice

In the case study the victim was shot several times. Later the police searched the house of the main suspect and found the murder weapon. The body and the weapon were investigated by the NFI. The NFI established that the victim was shot five times and died because of that. The NFI also established that the gun found in the suspect's house was the weapon used in the murder.

Problems

In the case study this step did not give any problems. The victim was shot several times and this was supported by a report from the NFI. The murder weapon was later found in the house of the perpetrator and was tested by the NFI to confirm that this was indeed the weapon used in the murder.

Cause	Argument
death by multiple shots	Supported by the section report (NFI)
	Bullets found in the ground at the crimescene
	bullet found on/in the body

Figure 31: the cause of death

Solutions

3.8.3 Hybrid theory 1.0 step

In step six in the hybrid theory the cause of death and weapon used in the crime will be described. Both these concepts needs to be supported by evidence coming from the chronolist. The result of this step is shown in figure 31 and 32.

Weapon	Argument
Pistol found in house of Adam	stated in coroners report
	Found bullet is from pistol
	NFI determined that found gun is same as the gun used for the murder
	Gun found in the house of Adam together with ammo (same size as murder ammo)

Figure 32: the murder weapon

3.9 Create story schemes as the basis for stories.

3.9.1 Description

Using story schemes to create stories gives a basis to create stories about the crime. The story schemes will help to give structure to the stories and help to see which story elements are missing.

3.9.2 Practice

In the case study 7w's were filled with different possibilities that were left after using the evidence and walking through the previous steps. The w's that differed the most were the who and why. The other w's were determined quite early in the investigation. For example "what and where" were determined when the coroner had inspected the body at the crime scene. But "who and why" were not clear during the largest part of the investigation. Speaking with analysts teaches us that this is normal in most of the cases they work on.

During the case study this step was also used to fill out the story scheme. So in this step a story scheme is chosen to apply for the stories together with the practical filling of the story scheme which will form the basis for the stories in the next step.

Problem

In the hybrid theory there is no practical information on which kind of story schemes to use.

Solution

Using the police practice the 7w's are chosen as the story scheme for the stories in the hybrid theory method. The 7 w's is a technique used by the police to cover most important questions about a crime. The 7 w's are:

1. Wie (who) (figure 33)

2. Wat (what) (figure 33)
3. Waar (where) -> crime scene (figure 34)
4. Waarmee (with what) -> means (figure 33)
5. Welke wijze (which way) (figure 34)
6. Wanneer (when) (figure 34)
7. Waarom (why) -> motive (figure 35)

who	what	with
Adam	Dead man in the park (Tim)	Pistol found in house of Adam
Adam & Renee	Dead man in the park (Tim)	Pistol found in house of Adam
Renee	Dead man in the park (Tim)	Pistol found in house of Adam

Figure 33: who, what and with

which way	where	when date	when time
death by multiple shots	park	23-7-2015	
death by multiple shots	park	23-7-2015	
death by multiple shots	park	23-7-2015	

Figure 34: which way, where en when

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why	Pro	Contra
Third robbery, defence or make a statement	man is aggressive / owns a gun/ is robbed before by the victim/ his car is seen around the crime scene at the time of the crime	denies he knows who robbed him /denies killing someone
planned to kill the robber	man is aggressive / owns a gun/ is robbed before by the victim/ his car is seen around the crime scene at the time of the crime	Adam says they were together around the time of the murder at his house/ Renee says he left at 24.00
Revenge for stealing from his friend	had acces to the gun and car / knew about the robberies / vague story where he has lost his ride information from his car from the month of the murder	says he doesn't know who robbed Adam/ says he doesn't know Adam has a gun

Figure 35: why and the pros and cons for the story

In figure, 33, 34 and 35 the three final stories are represented. In the next step the 7w's are made into stories.

3.9.3 Hybrid theory 1.0 step

In practice a story scheme will have to be chosen first. Together with the police the choice was made to use the 7W's in the case study. These 7 w's will be used in step six "story schemes". The idea is that most of the w's are filled by the time step six is reached. If a w is still open then this gap can be filled with reasoning or the w can be filled later in the investigation. An analyst can use the open w's to steer his investigation and see which information about the crime is still unclear. Each of the w's should be deducted from a previous step in the hybrid theory method. This would ensure that all the information that ends up in the story scheme has been reasoned about before it is used.

"Who" should come from step three "suspects". All potential suspects are mentioned in step three. The suspects who have a high priority will be used first in the creation of story schemes.

"What" will be answered in step 1 where the police report of the analysis of the crime and crime scene are mentioned.

"Where" is answered in step 4 where the crime scene(s) is described.

"With what" and "which way" is answered in step seven where the murder weapon is described.

"When" is inferred from step one. The time of the crime is usually inferred from witness statements or other evidence. In the chronolist there is room for mentioning a time indication.

"Why "is answered in step three. In step three the potential motives for each suspect are given. This motive will be the reason why the crime is committed. The result of this step is depicted in figure 33, 34 and 35.

3.10 Create stories

3.10.1 Description

To understand what has happened stories have to be created. These stories can be compared using arguments which attack or support stories. The stories will be modeled as timelines in the same manner as Bex does in his book in chapter six. Bex creates timelines in his book for each possible scenario he discusses. The timelines are formed with a time, a description and if possible a piece of evidence. Like the stories of Bex each point on the timeline is ideally supported by evidence, but is not necessary. In the hybrid theory method this evidence is coming from step five. This ensures that each point on the timeline is based on evidence gathered in step one.

3.10.2 Practice

Using the story schemes from the previous step it is possible to create different stories. In practice some parts of the stories will be the same in each story. For example in the case study the fact that Tim was shot in the park with a gun was the same for each story. However, who shot him and why differed per story. This means that the basis of all the stories is the same in the case study.

Using only the first batch of evidence nineteen stories were left. These stories were all short and undetailed due to the lack of supporting evidence. The stories ranged from being killed by people in the drugs scene for money or drugs to revenge for robberies committed by the victim.

Stories are made manually in this case study. There is no automatic way yet of forming stories based on the story schemes. In the case study the filled out story schemes were used to form the basis of each story. The 7W's determine which persons are in the story and which motive is the basis for the crime. Together with the statements from the chronolist stories are made manually.

The evidence in the case study was divided into two parts. One part was the first three weeks of the investigation before new crucial information was found, the second part was after the crucial information was found. This is further explained in the next chapter. When the second batch of evidence was used only three stories remained. These stories were all a bit more elaborate and had a higher amount of evidence supporting them. The following three stories were left:

1. Adam is victim of two robberies by the murder victim (Tim). Tim tries to rob Adam for a third time at night in the park. However, this time Adam has his gun on him and shoots Tim in the park. Adam then drives away in his car. This story can be seen in figure 36.

Time	event
	Adam is robbed by the victim
23:10-23:30	Victim is seen in the park
23:30	Victim drives away on his bike together with other man
23:30-03:00	**Adam is robbed for the third time by the victim**
02:30-04:50	Adam shoots the victim in the park
02:33	Adam drives away with his red car
02:30-04:50	Victim dies of shotwounds
04:50	Victim is seen lying in the park

Time	event
	Adam is robbed by the victim
23:10-23:30	Victim is seen in the park
23:30	Victim drives away on his bike together with other man
23:30-03:00	Adam and Renee search the victim and kill him
02:30-04:50	Adam shoots the victim in the park together with Renee
02:33	Adam & Renee drive away with Adams red car
02:30-04:50	Victim dies of shotwounds
04:50	Victim is seen lying in the park

Figure 36: example of two stories

2. Adam is victim of previous robberies by the murder victim (Tim). Adam goes to the park with his friend Renee to kill Tim as revenge for the robberies. One of the two men shoots Tim and they leave together in Adam's car.

3. Renee knows Adam has been robbed before by Tim. He decides to take revenge for the robberies. Renee takes the car and gun from Adam and goes to the park. There he shoots Tim. After shooting Tim, Renee returns the car and the gun to Adam's house.

Problem

There are potentially many stories that can be created. This is mainly caused by the number of suspects and their motives. If a lot of suspects are left in step 3 and many motives remain, then for each possible combination of suspect and motive a story has to be made.

Solution

No real solution is found for the number of stories that are left in step eight. Usually in practice the police uses these often undetailed stories to continue their investigation. Finding new information helps attacking suspects and motives, which will reduce the number of stories left in this step. In the case study this was

simulated using the second batch of evidence which was the evidence following the tipping point in the investigation.

3.10.3 Hybrid theory 1.0 step

Step eight is creating stories using all the information coming from the previous steps. The base of each story is found in the previous step (the story scheme) each story scheme creates a story in this step. Stories have, unlike the story schemes, a timeline with events. These events are all given the evidence which supports or attacks the event. This evidence is used in step nine.

It should be noted that the step from story schemes to stories is a small step according to Bex. However in practice many modifications and manual changes have to be made to go from story schemes to stories. Story schemes form the basis of stories but many details which do not occur in story schemes are present in stories. These details need to be filled out by the investigator and have to be supported by evidence.

3.11 Case study part two

In the case study, the evidence was divided into two parts. The first three weeks of the investigation were put into the first part of the case study. After these three weeks, there was a tipping point. The evidence of this tipping point and the evidence that followed this tipping point was put in the second part of the case study. This was done in order to see what the hybrid theory method could do in the police practice. The first part shows what the hybrid theory method can do with limited information and the second part of the case study shows what the hybrid theory method can do with almost all the available evidence.

Since the evidence was divided into two parts (before and after the final tipping point), the case study was also divided into two parts.

Step eight was the final step in the first part case study since there were too many vague stories which had to be used in step nine. Since all the stories were too small and did not have enough distinguishing evidence to make stories stand out from each other.

In the second part of the case study all the evidence from after the tipping point was added to the chronolist. This evidence helped to give some more information about the murder and the potential perpetrator(s). For example, the murder weapon was found after the tipping point and after the murder, a camera had recorded a car driving away from the crime scene. The owner of the gun owned a car that resembles the car on the video. All this info was added and this lead to some changes in the hybrid theory method:

Using the second batch of evidence it is possible to reason about these three stories.
The second part of the case study altered a few steps of the hybrid theory method

1. The new evidence was added to the chronolist
2. Step two remained the same although some more info on the victim and the relation with the possible perpetrator was added
3. One new person was added to the suspect list, the main suspect was already in the list on a high priority. All other suspects were given a lower priority since this new information was heavy enough to deprioritize all the suspects except for three of them.
4. Crime scene remained the same
5. The new evidence was added to the evidence sortation
6. New story schemes were added using filling in the new information into the 7w's
7. The murder weapon was now known. The information about the murder weapon was added in this step

8. All old stories were archived and the final three stories are created and linked to the evidence from step one and five.
9. The final reasoning was performed using the hybrid theory and the three final stories made in the previous step.

The reason that it was possible to perform step nine in the second part is that if the number of high priority suspects in step three goes down, the number of stories in step eight goes down and this makes it easier to reason with the remaining stories. In the case study, the number of stories went down from nineteen to three. Each remaining story had a higher support by evidence. The combination of both these factors leads to a workable situation to start step nine.

The 7w's of the final three stories are:

7W's	Story 1	Story 2	Story 3
who	Adam	Adam& Renee	Renee
what	Dead man in the park (Tim)	Dead man in the park (Tim)	Dead man in the park (Tim)
where	park	park	Park
with what	Pistol found in house of Adam	Pistol found in house of Adam	Pistol found in house of Adam
which way	Multiple shots	Multiple shots	Multiple shots
when			
why	robbery /defense	Plan to kill robber	Revenge for stealing from his friend

These 7w's create three stories. As mentioned before forming these stories is done manually. The who of the 7w's is used to define the perpetrators of the story, the what, where, with what and which way create the crime itself. When defines the time when the crime has happened. The story is built around this time. Why is the motive for the crime. This can also be one or more events happening before the investigated crime. The filling for the stories is deducted from the statements in the chronolist. The three stories which are used for the final step are:
- Story one is the story where Adam goes to the park. In the park Tim tries to rob him again. Adam shoots Tim when Tim tries to rob him. Tim dies of the shot wounds. Adam drives home with his car and Tim is found later that night.
- Story two is the story where Adam and his friend Renee go to the park to find the robber of Adam. They go to the park together in Adam's car. In the park they find Tim and shoot him. Tim dies of his shot wounds. Adam and Renee leave the park together in Adam's car.
- Story three is the story where Renee acts alone. Renee takes Adam's gun and car and drives to the park. There he finds Tim and shoots him because he knows that Tim has robbed his friend Renee. Tim dies of his shot wounds. Renee returns to Adam and puts his car and gun back where they were.

As seen in the stories each of the W's returns in the stories. The W's are the basis for each story. This means that each element or W needs to return in the story. The W's also show which elements differ per

story and which elements are the same. The three stories will be used in the next step to find the best story and exclude the stories that are not compatible with the evidence.

Figures 37, 38 and 39 in the appendix represent the three stories. They are used for reasoning in the next step.

3.12 Final reasoning and finding the truth

3.12.1 Description

The hybrid theory states that events can be supported or attacked by evidence. This is also represented in the last step of the hybrid theory method. Here all the evidence related to an event is collect per event. Then this evidence is split up between attacking and supporting evidence. This is done in order to see which evidence attacks or supports which event. The hybrid theory also collects evidence which attacks and supports events. The hybrid theory then either uses this evidence to attack or support an event directly or to attack or support other evidence. This is also done in the hybrid theory method.

This final step uses reasoning to find the most likely story. Step nine consists of five sub steps in the hybrid theory method 0.1. Because of how the hybrid theory method was executed in practice the first two sub steps, "make different stories" and support each story with evidence" are already executed in previous steps. Therefore, these steps can be skipped when executing the hybrid theory method 1.0.

The next step is to fill evidential gaps. This could be a step in practice where the detectives are sent on assignments to fill the gaps that are still present in the stories. However, during the case study this was not possible. All the evidential gaps that could have been filled are filled during the previous steps. It was not possible to ask for new evidence or send out detectives during the case study. Therefore, at this point in the case study each evidential gap that could have been filled is filled.

The following step is to attack each story with evidence. In step eight all the evidence that either supports or attacks the point on the timeline are gathered. This evidence can be used to attack stories. The first thing to do is to distinguish between supporting and attacking evidence for each story (point). After the splitting in supporting and attacking evidence the stories are compared to each other. This is done manually, per story point the attacking and supporting arguments are supported. Then the arguments are manually compared by the analyst. For now there is no automated way of comparing which conflicting arguments is stronger. When comparing the arguments the analyst can look at the source of the argument or the nature of the argument in order to decide if the story point holds or is defeated. When all the story points of a story hold, then this story might be close to what happened in real-life. When a lot of story points are defeated by arguments this means that this story is not very likely to have happened.

In this section scores for arguments will be introduced. These scores are introduced to solve a problem encountered in practice. The scores are based on law. In law police statements are rated the highest, after police statements expert testimonies are considered very reliable. Witness statements are considered the least reliable. These reliabilities are translated into scores. The choice is made to represent these reliabilities into scores of 3,2 and 1. How these scores are used will be explained later in this section.

Argumentation can be difficult to apply in practice. To demonstrate how the reasoning with stories and arguments would work in practice the final three stories are made into stories and arguments. Below the stories the argumentation which is applied for each story is explained. After the explanation the problems with reasoning with stories and arguments in practice are explained.

Figure 37, 38 and 39 in the appendix represent the three final stories which were made using the evidence from the case. The first thing that stands out is that the stories are not really detailed. The events represented in these schemes are all events that are derived from the evidence. This is also the reason that many events from the different stories are the same in each of the three schemes. The events that are similar in each story are also the events which are undisputed and supported by evidence. Therefore these events are most likely to be true. The rest of the events need argumentation since there are arguments supporting and attacking the event or there is no evidence at all about the event which leads to an evidential gap. The events that have evidence supporting and attacking them need reasoning to find out if the event is likely to have happened or not.

There are some problems with this argumentation and story approach.

Argumentation is shallow: the argumentation performed with these three stories is shallow. It only uses argumentation between two or three arguments and often the argumentation does not go further than Adam or Renee saying they were not there and some piece of evidence contradicting that statement.

When is an argument defeated and when is an argument strong enough? Without giving values to arguments it is difficult to determine when an argument is defeated or when the argument stands against its attacking argument.

No depth in the stories: The stories represented in figure 37, 38 and 39 are the most detailed stories that can be made using the evidence. Every event that would be added to any of the story would create an evidential gap.

It is only possible to compare stories to each other: the reasoning and comparing of stories can only give an image on which of the stories is the most likely compared to the other ones. It does not give an image of how likely it is to the real events of the crime.

No clear border when is story good enough to arrest someone and take him or her to court: When a story is the most likely of the stories created based on evidence. It is still not clear if this story is enough to arrest someone and take him or her to court. This problem is not only bound to using the hybrid theory reasoning and might be solved by leaving the decision off arresting and prosecuting to the prosecutor.

Bex proposes rules in his book about the hybrid theory [1] which could solve the problems stated above. These rules follow a more ordered and mathematical approach to comparing stories.

- If $E_+(S_i) \subset E_+(S_j)$ and $E_-(S_i) \supseteq E_-(S_j)$ then $S_i < S_j$
- If $E_+(S_i) \subseteq E_+(S_j)$ and $E_-(S_i) \supset E_-(S_j)$ then $S_i < S_j$
- If $E_+(S_i) = E_+(S_j)$ and $E_-(S_i) = E_-(S_j)$ then
  − If $P_+(S_i) \subset P_+(S_j)$ and $P_-(S_i) \supseteq P_-(S_j)$ then $S_i < S_j$
  − If $P_+(S_i) \subseteq P_+(S_j)$ and $P_-(S_i) \supset P_-(S_j)$ then $S_i < S_j$
  − If $P_+(S_i) = P_+(S_j)$ and $P_-(S_i) = P_-(S_j)$ then
  - If $E_G(S_i) \supset E_G(S_j)$ then $S_i < S_j$
  - If $E_G(S_i) = E_G(S_j)$ then $S_i = S_j$

Bex proposes two sets of rules in order to compare stories. In these rules two stories S_i and S_j are compared. This is done using the undisputed evidence E. The undisputed supporting evidence is E_+ and the undisputed attacking evidence is E_-. P_+ and P_- stand for probability and improbability. E_G stands for evidential gaps in the story. In this set of rules stories are first compared on their coverage and contradiction by evidence. These rules are applied on the stories in the appendix figures 37, 38 and 39. To determine the supporting and attacking evidence only the evidence that is not undercut can be used. The evidence that is not undercut is:
- Declarations made by Adam at the police station (E1)
- Testimony of Renee and Adam (E2)

- Not literally said that he was robbed, just that he did not let it happened the third time (E3)
- Adam says he was not there (E4)
- Alfred sees Tim in the park (E5)
- Renee says he does not know Adam has a gun (E6)
- Renee says he went home (E7)
- Report of NFI: Tim dies of shot wounds (E8)
- Car like Adam's is seen (E9)
- Alfred testifies that he saw the victim lying in the park (E10)
- Adam says he has a gun (E11)
- Gossip that Renee knows who robbed Adam (E12)
- Renee says he was not there (E13)

For the rules of Bex the set of evidence supporting the story 1,2 and 3 (S1, S2 and S3) is E+(S1)= {E1,E5,E8,E10,E11},E+(S2) = {E1,E2,E5,E8,E10} and E+(S3)= {E1,E2,E3,E5,E8,E10,E12}. The evidence attacking story 1,2 and 3 is E-(S1)={E3,E4,E9 }, E-(S2)={E3,E4,E7,E9} and E-(S3)={E6,E7,E9,E13}. Now it is possible to apply the rules proposed by Bex.

Story 1, 2 and 3 cannot be compared because they have different sets. Story 2 and 3 have comparable E+ but incomparable E-. Story 1 and 3 have incomparable E+ and E- and story 1 and 2 have incomparable E+ and comparable E-.

Given two explanations S_i and S_j, a total preordering function $\leq_a$ can be defined as follows:
- If $|E_+(S_i)| < |E_+(S_j)|$ and $|E_-(S_i)| \geq |E_-(S_j)|$ then $S_i <_a S_j$
- If $|E_+(S_i)| \leq |E_+(S_j)|$ and $E_-(S_i) > |E_-(S_j)|$ then $S_i <_a S_j$
- If $|E_+(S_i)| = |E_+(S_j)|$ and $E_-(S_i) = |E_-(S_j)|$ then
  - If $\exists G_{s1} \in$ Schemes such that S_i completely matches G_{s1} and $\neg\exists G_{s2} \in$ Schemes such that S_j completely matches G_{s2} then $S_i < S_j$; otherwise
  - If $\exists G_{s1} \in$ Schemes such that S_i is complete w.r.t. G_{s1} and $\neg\exists G_{s2} \in$ Schemes such that S_j is complete w.r.t. G_{s2} then $S_i < S_j$; otherwise
  - If $|P_+(S_i)| < |P_+(S_j)|$ and $|P_-(S_i)| \geq |P_-(S_j)|$ then $S_i <_a S_j$
  - If $|P_+(S_i)| \leq |P_+(S_j)|$ and $|P_-(S_i)| > |P_-(S_j)|$ then $S_i <_a S_j$
  - If $|P_+(S_i)| = |P_+(S_j)|$ and $|P_-(S_i)| = |P_-(S_j)|$ then
  - If $|E_G(S_i)| > |E_G(S_j)|$ then $S_i <_a S_j$
  - If $|E_G(S_i)| = |E_G(S_j)|$ then $S_i =_a S_j$
Where $|S|$ stands for the number of elements of set S.

This means the second set of rules will have to be used to compare stories.
The second set of rules look at the absolute number of elements in order to compare stories.
This set of rules is used to compare S1, S2 and S3. |E+(S1)|= |E+(S2) | and |E-(S1)|< |E-(S2)| thus these stories are incomparable using the rule of Bex. |E+(S2) |< |E+(S3)| and |E-(S2) | = |E-(S3) | according to the rules created by Bex these stories are also incomparable. |E+ (S1) |< |E+(S3) | and |E-(S1) | < |E-(S3) |. This also makes story 1 and 3 incomparable. This means all stories are incomparable using the rules proposed by Bex.

There are some difficulties with this method of working. Bex uses only evidence that is undisputed. This means that in practice a lot of evidence would be lost. For example, a statement made by a drug addict

can be undercut by the argument that drug addicts might not tell the drugs because of their drug use. This means none of these statements can be used in these rules.

Both set of rules are also difficult to apply since most of the time the sets of evidence can differ quite a bit. This makes them incomparable with each other when the first set of rules is used. The second set of rules could be easier to apply in practice because the number of elements is used instead of the sets themselves. However, in the example from the case study the second set of rules does not allow the stories to be compared to each other.

3.12.2 Practice

For the reasoning in step nine the three remaining stories from step eight were used. The stories that remained were: Adam killed the victim, Adam and Renee killed the victim or Renee killed the victim. The two robberies of Adam by the victim, Tim, were almost certainly the events that lead to the murder. This was also the only link between the victim and the murderer(s). To determine which of the three stories was the most likely to have happened in real life, arguments were used. Arguments are created in the first step of the hybrid theory method. In step one the statements and information coming from evidence are made into single arguments. These arguments are used in the entire hybrid theory method. In step nine they are used for finding the best story. For the case study the rules from Bex were the basis for comparing stories. However, a few changes were made. In practice an altered version of the second ruleset of Bex is created to compare stories. One of the main differences is the evidence used in the comparison of stories. Bex defines supporting or attacking evidence as evidence that is non-overruled. This means in practice that a lot of evidence is not taken into account when comparing stories. In practice the police does want to take this evidence into account. Therefore, a weight has to be given to each piece of evidence. This allows the use of each piece of evidence, but also takes into account that some pieces of evidence are stronger (more reliable) than others.

It is also important to state what happens if multiple people state a same argument. Does this become multiple arguments or does this count as one argument? For the example the choice is made to combine multiple of the same statements into one statement.

In the case study each piece of evidence is given a value. This value can be either 1, 2 or 3. The choice is made to give a witness statement a value of 1, an expert testimony a value of 2 and a police testimony a value of 3. This score can be used as a positive (support) score for the story or a negative (attack) score against the story. The scoring off evidence is done because giving certain pieces of evidence a score makes it possible to mathematically compare stories. Giving score also allows some evidence to be more important than others. For example a statement from the police which is contradicted by a statement from a witness will both be used for supporting or attacking a story but the statement from the police will have a bigger impact on the strength of a story.

When applying the rules of Bex each of the stories from the case study becomes incomparable. To compare the stories a new set of rules is made. For the comparison of stories two sets of evidence are created, the supporting and the attacking set of evidence. Each set is composed of three subsets of evidence. These subsets are the sets of evidence with different values. A set for evidence with the score of 1, a set for the evidence with the score of 2 and a set for the evidence with the score of 3. For the supporting and attacking sets of evidence the following rules are made:
-   Support $E+ = \{|E+1| + 2*|E+2| + 3*|E+3|\}$
-   Contradiction is $E- = \{|E-1| + 2*|E-2| + 3*|E-3|\}$

These rules are used in practice to create a strength of a story. This strength score can be used to compare stories with each other. The strength of a story (T) is determined by subtracting the value of contradiction E- from value of the support E+. This leads to the following rule:

- The total strength of a story is $T = |E+| - |E-|$

The strength of each story is needed in order to compare them. These scores will be compared using the following rules:

- IF $T_j > T_i$ then $S_j > S_i$
- IF $T_j = T_i$ then $S_j = S_i$ This means further investigation has to be done to determine the best story

These rules show that if the strength of a story "j" is bigger than the strength of story "i", then story "j" is better than story "i". If both stories are evenly strong then more research has to be done. This is a difference with Bex his theory. In Bex his theory it is possible to come to the conclusion that stories are incomparable, this is however in practice not possible. The police needs to be able to compare scenarios with each other given the evidence they have. The conclusion that stories cannot be compared is therefore changed to the action "more research is needed in order to get the best story".

The proposed set of rules is applied to the three stories of the case study. First the set of evidence is determined with their values. As mentioned before each piece of evidence is considered in the proposed method.

- Declarations made by Adam at the police station (E1) (1)
- Alfred sees Tim at the park (E2) (1)
- Telephone conversation between Adam and his Son where he says that he didn't let him rob him for the third time (E3) (3)
- Not literally said that he was robbed, just that he did not let it happen the third time (E4) (1)
- Report of the NFI :gun found in the house of Adam used to kill Tim (E5) (2)
- Gunshots heard by neighbors (E6) (1)
- Adam says he has a gun (E7) (1)
- Adam says he was not there (E8) (1)
- Report of NFI: Tim died of shot wounds (E9) (2)
- Adam's car is seen on video (E10) (3)
- Car like Adam's is seen (E11) (1)
- Alfred Testifies that he saw the victim lying in the park (E12) (1)
- Testimony of Renee and Adam (E13) (1)
- Renee says that he went home (E14) (1)
- Renee says he doesn't know Adam has a gun (E15) (1)
- Gossip that Renee knows who robbed Adam(E16) (1)
- Renee says he was not there(E17) (1)

The score behind the evidence is given following the rule that witness testimonies get a score of 1, expert testimonies a score of 2 and police statements get a score of 3.

The E+ (S1) = {|E1, E2, E6, E7, E12|, |E5, E9|, |E3, E10|}, E-(S1) = {|E4, E8, E11|,|/|, |/|}. The E- (S2) = {|E1,E13,E2,E6,E1|, |E5,E9|, |E3,E10|} , E-(S2) {|E14,E4,E8,E11|, |/|, |/|}. The E+ (S3) = { |E1,E13,E2,E16,E4,E6,E12|, |E5,E9|, |E10|} , E-(S3) = {|E15, E14,E17,E11| , |/|, |E3|}. Now that the sets are known, the strength (T) of each story can be determined. For T(S1) = 16- 3 = 13, T(S2) = 15-4 = 11 and T(S3) = 14-7= 7. So T(S1) > T(S2) > T(S3), this means S1>S2>S3. According to the proposed rules story one is best supported by the evidence from the case. The score also shows is stories are just a bit weaker or much weaker. This can be taken into account when stories are discarded for further investigation. For example the

between T(S1) and T(S2) is only 2, while the difference between T(S1) and T(S3) is 6. This bigger difference means that story 3 is much less supported by evidence than story 1 or 2.

One of the problems with this method is the determining strength of an argument. For the strength of an argument the number of times an argument a stated by a different source does not have any influence on the score. For example if 10 people state that they heard a shot, then this argument still gets a score of 1. This is because the same argument is only applied once for each story. To counter this problem a scoring system could be applied where the number of independent sources gives a bonus to the argument. This could be done by multiplying the score with the number of independent sources that state the argument. The sources do have to be independent. For example if 10 people say they heard from the same person that someone was shot then this argument still counts for one. This is due to the fact that none of the sources are independent from each other but all got their information from one source.

Another issue with this method of reasoning is that longer stories are favored over shorter stories. This is because each event, when supported, is adding to the total strength of a story. The reasoning could be that longer stories are better than short stories because they elaborate more. However if the amount of events should not play a role in the strength of a story, then it is also possible to calculate the average strength per event. This is done by dividing the total strength of a story by the number of events of the story. This gives an average which can also be compared.

3.12.3 Hybrid theory 1.0 step

The ninth step of the hybrid theory method consists of three sub steps. In the first sub step all the evidential gaps are filled using evidence from the chronolist. The aim for this sub step is to try to make the stories as complete as possible with the information available in the investigation, coming from the chronolist. This is done looking at the evidence sorted in step one and five. For each event the idea is that all evidence that is related to that event is collected. This can be evidence supporting or attacking the event.

The second sub step is arguing about the stories. This is done by dividing the evidence for each story point in supporting and attacking evidence. Then the supporting and attacking evidence is given a value depending on if they consist of police statements, expert testimonies or witness statements. Corresponding the evidence receives the value of 3, 2 or 1. Then the strength of each story is calculated by deducting the attacking set of evidence from the supporting set of evidence. This gives the strength per story and this score is compared. The story with the highest strength is the story which is the most likely to represent the truth using the evidence at hand in the case.

3.13 Hybrid theory method 1.0

Using the lessons learned in the case study an improved hybrid theory method is created. This method is based on the hybrid theory method created at the end of the literature study and improved to handle the problems encountered in practice.

1. Create chronolist to collect and summarize the evidence which is present in the investigation
2. Step 2 remains the same as the first version of the hybrid theory method: Identify the victim. One of the first things to do is to understand who the victim is. What is his or her name, age, social milieu and other facts.
3. The third step in the hybrid theory method exists of finding suspects. In order to be able to reason more easily about the suspects in a case the third step was divided in four sub steps. The first sub step is making a list of all the people involved in the case.

The second sub step is giving each person from the list a role.

The third sub step is excluding the roles using arguments.

Sub step four lists all the different people with a suspicious role. Per person their name, gender, relation to the victim and potential motives are stated.

4. Step four has remained the same as in the first version of the hybrid theory method: Define location of the crime scene (if not known from the beginning). Describe the location where the body is found to identify possible flight routes and cameras which could be useful for the investigation. If the body has been moved, the real murder scene has to be found as well.

5. Step 5 has been specified, the division of evidence is done in three categories and under each category a subcategory. The categories are motive, means and opportunity. The three subcategories are: police document, expert testimony and witness testimony. The main categories have been created using a model of the police, the subcategories have been created based on the theory of F. Bex.

6. Step seven and six will switch in practice. It is more logical to first determine the cause of death before creating the possible stories about what has happened. Step six is now determining the cause of death of the victim. This includes determining the weapon and injuries, which have caused the death of the victim.

7. Creating story schemes, which is now step seven, has been specified to be able to use this step in practice. The stories schemes are created using the 7w's. This is a technique used by the Dutch police force. The 7w's are deducted from the previous 6 steps. No new information should be added in this step.

8. Step eight is the effective creating of the stories. This is done using timelines. The timeline is created using only facts and times based on evidence out of the chronolist. Each point on the timeline is linked to its supporting evidence. This way it becomes clear which point on the timeline are deducted from evidence and which ones are created to make the story clearer (but are not supported by evidence)

9. Consists of three sub steps to eventually come to the final story.

First, all the evidential gaps are filled using evidence from the chronolist. This step tries to make the stories as complete as possible with the information available in the investigation.

Secondly, when the stories are as complete as possible the arguing about the stories is executed. This is done by splitting the evidence for each story point in supporting and attacking evidence. Then the supporting and attacking evidence is given a value depending on if they consist of police statements, expert testimonies or witness statements. Corresponding the evidence receives the value of 3, 2 or 1. Then the values of the attacking arguments are deducted of the values of the supporting arguments. This gives the strength per story. The strength gives an idea if the story in total is better than the other stories.

The story that remains with the highest strength can be used as the best story created with the hybrid theory method.

Figure 40 in the appendix represents the process delivery diagram (PDD) of the hybrid theory method 1.0. This diagram shows all the steps of the process and shows which deliverable come from each step. Below the PDD are the activity and the concept table. These tables explain in short the activities on the PDD and the concepts used in the PDD.

Activity	Sub-activity	Description
Create chronolist		Gathering statements from the evidence and collecting them in a CHRONOLIST
Identify the victim		Create a summary of the VICTIM
Find suspects	List people	Create a list of all PEOPLE
	Give roles	Give each person a ROLE
	Exclude roles	Exclude a ROLE using statements from the CHRONOLIST
	List suspects	Create a list of SUSPECTS from the ROLES which are suspicious.
Define crime scene		The CRIME SCENE describes the place where the crime has taken place.
Categorize evidence		Organize the evidence from the CHRONOLIST in three categories.
Determine cause of death and murder weapon		The MURDER WEAPON AND CAUSE OF DEATH is the summary of all the information known about the murder weapon used in the crime and the cause of death.
Create story schemes		Using the 7w's the VICTIM, SUSPECTS , CRIME SCENE and murder weapon are put into STORY SCHEMES
Create stories		Use STORY SCHEMES AND ORGANIZED EVIDENCE to create STORIES
Final reasoning	Fill evidential gaps	Fill the gaps in the STORIES
	Attack stories	Use ARGUMENTATION to attack STORIES
	Keep final story	Using ARGUMENTATION and STORIES a final Story should remain that depicts the closest what happened during the crime.

Table 1: activity diagram

Concept	Description
CHRONOLIST	The CHRONOLIST is a list containing all the statements coming from the evidence in the case. Each statement has a time, a person who stated the statement, the person the statement is about, the statement itself and a reference to the evidence where the statement came from.
VICTIM	The VICTIM is a summary of the victim containing his name, age, nickname, social milieu, nationality and gender
PEOPLE	Is a list of all PEOPLE in the investigation with their name
ROLE	A ROLE is created in an investigation and helps to group the PEOPLE in the investigation.
SUSPECTS	SUSPECTS are the people left after their role is marked as suspicious with high priority. This list contains the suspects name, gender, relation to the victim and the potential motives for the crime.
CRIME SCENE	CRIME SCENE is a description of the location where the crime took place. This description contains a map of the location, the groups of people who come there often and the name of the location.
ORGANIZED EVIDENCE	ORGANIZED EVIDENCE is all the evidence from the case, organized in categories created by the analyst. The evidence is divided into motive, means and possibility. Each of these categories has three sub-categories: police statement, expert testimony and witness statement.
STORY SCHEMES	STORY SCHEMES are schemes for stories created using the information from CRIME SCENE, SUSPECT LIST, VICTIM and the CHRONOLIST. These schemes form the basis for the creation of STORIES. The STORY SCHEMES are based on the 7w's used by the police.
MURDER WEAPON AND CAUSE OF DEATH	The MURDER WEAPON AND CAUSE OF DEATH summarize the information about the weapon used in the murder and the information about the death of the victim.
STORIES	STORIES are timelines with events and times. Each of the point on the timeline has evidence that is connected to the event.
ARGUMENTATION	ARGUMENTATION is a combination of supporting and attackting evidence. Using these against each other results a story being falsified or not
FINAL STORY	IF SUPPORTED STORIES have gone through ARGUMENTATION one FINAL STORY remains. This story should be the story which stand closest to the truth.

Table 2 concept table

4. Results

This chapter summarizes the whole thesis research and all its aspects. After that the research questions will be answered using the results from the previous chapters. Finally some future research will be suggested.

4.1 Recap

This thesis research set out to see how the hybrid theory could be put into practice. First research questions were made. To answer the theoretical questions and to set a theoretical framework a literature study was performed. From the literature study a first version of the hybrid theory method was created (hybrid theory method 0.1). This method was used as a basis for the case study. This case study used a real-life case from the Dutch police force. During the case study practical problems occurred when applying the hybrid theory method 0.1. For these problems solutions were sought and found and these were implemented. The result of this case study was an improved hybrid theory (hybrid theory 1.0). The next part of this chapter gives the answers to the (sub) questions posed in this thesis research.

In order to interpret the results, it is necessary to look at this thesis study in a bigger context. What are the results worth and how can they be applied to other cases? Since the hybrid theory was only tested in one case study, it is difficult to say what the results of applying the hybrid theory method in other cases will be. If for example in another case the determination of the crime scene and murder weapon are the most difficult. Then the steps in which the crime scene and the murder weapon are determined might have to be altered.

4.2 Answering the research questions

With the information and results gathered shown in the previous chapters the research questions can be answered.

RQ1: "How do the hybrid theory and the working procedure of the police relate?"
To find the answer to this question, it is important to know what the hybrid theory and the working procedure of the police comprises. For both the hybrid theory and the working procedures of the police the most important concepts and their relations have to be determined. Therefore sub questions 1 and 2 were created.

The answer to sub question 1 shows that the hybrid theory puts emphasis on stories, arguments and argumentation. Stories are supported by evidence which forms arguments. The police on the other hand uses the concepts stories, evidence, sources and the 7w's for solving crimes. The police looks at disproving stories, while the hybrid theory also tries to support stories.

Looking at the goals of both the hybrid theory and the working procedures of the Dutch police, they both want to find the true events that have happened during the crime. Both use stories or hypothesis that they compare in order to find the one best story or hypothesis. Both the Hybrid theory as the working procedures of the Dutch police try to discard untrue stories using arguments. The differences between the police working procedure and the hybrid theory are that the police working procedures do not show the path of reasoning followed by the investigator. The hybrid theory does show the argumentation followed to determine if events have happened or not. The hybrid theory puts more emphasis on argumentation and theoretical reasoning. The police working

procedures are more focused on working in practice and solving crimes and helping to advance the investigation by showing promising leads, which can be further investigated.

SQ1.1: What are the most important concepts in the hybrid theory and how are they related?
In the literature study the hybrid theory was studied. Looking at the description of Bex of the hybrid theory the main elements are stories, arguments and argumentation. Stories tell a series of events and explains the causal relation between events. Arguments are a chain of reasoning according to Anderson and colleagues. Bex uses the same definition. The arguments in the hybrid theory are used to perform argumentation about stories. Arguments can support or attack events directly or indirectly. The relation between the three main elements is that stories can be supported or attacked by arguments using argumentation.

SQ1.2: What are the most important concepts in the reasoning of the police and how are they related?
The most important concepts in the reasoning of the police are found through the literature study of the book "het recherche portret" [2] and through interviews with analysts of the Dutch police force. The most important concepts are stories, evidence, sources and the 7 W's. Just like in the hybrid theory stories are used to give an overview of events. The police does place more emphasis on making stories in the form of timelines. These events are created using the evidence they collect during the investigation. Events are the basis of each investigation and depending on the source of the evidence the evidence has more or less importance. The 7W's are the basis which the police use to create stories. The 7W's can be seen as the story scheme which the police uses to create stories. The police uses ACH in their investigations. This theory puts more emphasis on the proving of stories in contrary with the hybrid theory which puts more emphasis on the proving of stories. The attacking of arguments on other arguments is not possible in ACH.

RQ2: "How can the hybrid theory be made into a method which can be put into practice by the police?"
To find out if the hybrid theory could be put into practice it is important to answer some other questions first. Before the hybrid theory is put into practice it is important to know if there are other theories that could to apply the hybrid theory in practice. Therefore sub question 1 is created. During the case study there might be problems which the hybrid theory cannot solve because it misses certain elements which are needed in practice. These missing elements are written down in sub question 2. The last thing that needs to be assured is that the hybrid theory method holds the same quality as the hybrid theory. Therefore sub question 3 is created.

    The first sub question was answered in the literature study, however no other theories were applied in the case study. This was done in order to keep the hybrid theory as "pure" as possible. Keeping the hybrid theory clean from other theories also helps answering the second sub question. The missing elements become clear when the "pure" hybrid theory is applied in practice. The main missing element is a scoring system for evidence. This would make the reasoning with evidence about stories easier in practice. The practice is not as black and white as the hybrid theory makes us think it is. For the third research question the question proposed by Bex and Verheij are used. These questions represent the quality demands which the hybrid theory tries to achieve. The questions proposed by Bex and Verheij help reflecting on the hybrid theory method and the answers proof that the same quality as the hybrid theory is met.

Combining the previous answers leads to the answer that it is possible to put the hybrid theory into a method, although using only the hybrid theory will be very difficult in practice. Like in the hybrid theory method some adaptations will have to be made to make the hybrid theory applicable in practice. This is due to the fact that the hybrid theory mainly focusses on the reasoning in the end, when the information has been collected and the stories have been formed. Although not all practical problems can be solved using the hybrid theory alone, the reasoning as applied in the hybrid theory is used in every step of the hybrid theory method.

SQ 2.1: Which other theories can be used combined with the hybrid theory in order to make it usable?
During the case study it was decided that in order to really test the usability of the hybrid theory only the hybrid theory should be tested without any other theories. Therefore all problems encountered during the case study were solved using the hybrid theory or the police practice. This gives a clearer image of the usability of the hybrid theory in practice. The usage of the hybrid theory together with other theories can be done in future research together with the other future researches proposed in the next section.

SQ2.2: What concepts and tools have to be added to the hybrid theory in order to put it into practice?
The hybrid theory misses some elements in order to make it useable in practice. One of the main problems is that the hybrid theory comparison of stories is difficult. Sorting through a lot of evidence is not addressed in the hybrid theory. The most important miss of the hybrid theory is that it is a theory, the practical application is not explained and this becomes obvious when the theory is tested in practice. In practice the information is messier than implied in the examples cases on which the hybrid theory is explained. How to handle the selection and rating of evidence and arguments is not explained.

SQ2.3: what controls can be created to check if the same quality demands as the hybrid theory are present in the created method?
In order to test if the stories and arguments created in the hybrid theory method are made using the same criteria as the hybrid theory the six critical questions proposed by Bex and Verheij [8] are discussed. These critical questions are used to show that the base elements of the hybrid theory are still present in the hybrid theory method. These questions can be used to critically check the presented arguments and stories. They help to implement and apply the important aspects of stories and arguments according to the hybrid theory on stories and arguments. The questions (Q) are answered by the underlying thoughts and steps taken in the hybrid theory method (A).

   1. **Q: Are the facts of the case made sufficiently explicit in a story?**
A: in step eight all events are put together into stories. In step nine the evidence supporting, but also attacking the story, is presented. This can be seen as presenting the facts. The 7W's is the story scheme on which each story is based. Each step leading up to the story presents facts which determine each story element or one of the W's of the 7 W's. This leads to each story element of the final stories presented in step eight and nine will be supported by evidence.

   2. **Q: Is the story sufficiently supported by evidence?**
A: It is hard to answer this question. It is hard to determine when a story is sufficiently supported since support is not expressed in numbers. The hybrid theory method focusses on creating the best

story using the evidence available in the case. The result of going through the hybrid theory method can be that there are multiple stories which are poorly supported by evidence. This means that further detective work is needed. Even when the result of the hybrid theory method is one story supported by evidence, it is not possible to know if the story is sufficiently supported. This can only be tested when the story is used in a criminal case in front of a judge who will or will not sentence the suspect based on the story presented by the police. If the story is sufficiently supported by evidence the suspect will be prosecuted, if not then the judge will let the suspect go free.

3. **Q: Is the support that the evidence gives to the story sufficiently relevant and strong?**
   (c) Q: Are the reasoning steps from evidence to the facts in the story justified by explicit warranting schemes or generalizations that are valid and grounded?

A: The hybrid theory method shows reasoning step by step for each part of the story. Each step focusses on explaining and supporting the choices made for the final stories. For example the final suspects are filtered using arguments in step three. These final suspects are used in the final stories from step eight. This reasoning is clearly explained.

   (d) Q: Are there exceptions to the use of the schemes and generalizations that undermine the connection between evidence and facts?

A: A lot of the evidence from the case study comes from witnesses from the drugs scene. These people might be unreliable because many of the stories are gossip from other users. Another fact to take into account is that drugs users have a different perception of reality then non-drug users, so things the perceived might be different from what happened in real life.

4. **Q: Has the story itself been sufficiently critically assessed?**
   (c) Q: Is the story sufficiently coherent? Are there elements missing? Are there implausible events or causal relations? Is the story inconsistent?

A: Using the story schemes in step seven it is possible to see which pieces of the stories are missing. Each "w" should be filled out to complete stories. These are the important elements for stories. The coherence of a story however is not guaranteed with step seven. Coherence in stories proves to be difficult in real life. Most of the crimes never receive a full statement about what happened. The true events of the crime can only be derived from the statements of witnesses or expert testimonies. Since the story is derived it will never be highly detailed which might make the story less coherent. Using the evidence from the case to create the stories, we try to keeps the stories as plausible as possible.

   (d) Q: Is there evidence that refutes elements of the story?

A: In step nine all the evidence is divided into supporting and attacking evidence. For many of the story points there is supporting as well as attacking evidence. However, for most of the story points the supporting evidence is stronger than the attacking evidence.

   (c) Q: Have story consequences been used to test the story?

A: Story consequences have not been used in the hybrid theory method.

5. **Q: Have alternative stories been sufficiently taken into account?**

(c) Q: Has a sufficient search for alternative explanations been performed, not only in the investigative phase, but also in court?

A: If alternative explanations are handled in court is beyond the scope of this thesis. However, during the investigation phase multiple alternatives are considered in each step. Each step tries to eliminate as many alternatives as possible. There is no real step in the hybrid theory method that forces an analyst to create more alternative stories. However, the hybrid theory method does force him or her to think about every aspect of the story. When the analysist looks at the people in the investigation for example he or she needs to add all the people who have given a statement and all the people who are mentioned in the statements. Then he or she needs to reason about each person in order to exclude them from the stories later. If a person is not excludable then they need to be added to the stories later. This does force an analyst to create more stories if there are multiple choices for an element of a story.

(d) Q: Have the alternatives been sufficiently analyzed? Are there explicit reasons to choose one story over the alternatives?

A: In the hybrid theory method the stories are given values at the end of the reasoning. This is done by making a sum of all the values of the supporting evidence and deducting the sum of all the attackting evidence. This gives an end value to the story. When this value is positive this means that the supporting evidence is bigger than the opposing evidence. The higher this score the more evidence supports this story. In order not to favor longer stories against shorter better supported stories the average score is also calculated. This is the total score divided by the number of story points in the story.

6. **Q: Have all opposing reasons been weighed?**
   (a) Q: Have all considerations that are used to weigh opposing reasons been made explicit? Has this been done both at the level of individual facts and events and at the level of stories as a whole?

A: This is the point where the hybrid theory method tries to excel. It shows the reasoning about each story element. Each step of the hybrid theory method shows the reasoning about that element and how certain choices for that element are either used for the stories or discarded. This is all done using reasoning based on evidence. The final step also reasons about the whole story and shows its support by evidence.

4.3 Perspective and future research

In this section the research is put into perspective. The hybrid theory has been tested in one case study and this has brought up some discussion points. These points are important to consider if the hybrid theory method is tested and improved in future research. At the end of this section some of this future research to test the hybrid theory method is suggested.

4.3.1 Perspective

- **Value of points on the timeline and value of evidence can be deceptive (more evidence more points, but might not be better).**

Using a score where the total of points gathered from the story points is used is biased towards stories with more story points. Each story point can add points to the story which would mean that the longer the story the more points. More points means a better story. An argument for using the sum could be that more story points means a more detailed story. However, this raises the question if more less supported story points are better than a few heavily supported story points

- **A lot of steps are made arbitrary (choice of people in step 3 , step 9 entirely)**

The selection of people who are left after step 3 was done by an analyst of the police, who selected the final group of people who are used further in the hybrid theory method. This was done because with the hybrid theory method alone 31 people were left which made it very hard to continue with the next steps of the method. For step nine the values given to the evidence are arbitrary, the choice to give police testimonies 3 points and witness statements 1 point is a choice made to experiment with values. This does not mean that a statement from the police is three times as believable or useful as a witness statement.

- **Division and roles made to own insight**

The roles given to the people in the investigation are made to own insight. Why a certain person obtains a certain role is not supported by reasoning. This means each role is given by personal insight. This giving of roles can be biased and might cause that potential suspects receives a non-suspicious role. This can be dangerous in practice and has to be kept in mind when assigning roles to people.

The decision to give a person a certain role as well as when a role is suspicious is a personal choice. There are no real hard values or rules to determine when a person receives a certain role. There are no rules or tipping values to determine when a role is suspicious or obtains a high or low priority. This can lead to a biased investigation.

- **Values in general**

The values used in step 9 are not supported by research. Bex mentions that police testimonies are more reliable then expert testimonies which are more reliable then witness statements. But in step 9 these are given values ranging from three to one. These values are chosen to illustrate the credibility of the evidence. This comes with potential errors, if ,for example, four witnesses state that a red car was driving near the park, but a camera shows no car near the park, this would give a score of +1 for the scenario a red car drove past the park. Even though the physical evidence says this is not true. A possible solution could be that argumentation without numbers is used for these cases or different values can be applied. Physical undisputable evidence could be given an extremely high score so no other evidence can contest this.

- **Supporting evidence or attacking evidence that has multiple statements coming from the same source (multiple junkies stating stabbing , which was nog found in the report of the coroner).**

For example, when multiple people say they heard someone tell that someone was shot, but this all comes from the same source. Is it counted as one source or do all these people count as separate sources? When this only counts as one source, other statements have to be backtracked as well to see if they do not quote a same source but really state something independent. In the case study each source is counted separately. This is done because the idea is that if multiple different sources

tell the same story this might make it stronger. Though this is not always true. For example, multiple sources state that the victim was stabbed, but physical evidence proves this is not true. A solution could be that each additional source is given a lower score.

- **No hard value to determine if story is good or not, only compare to the others. Still no idea if story is good in general.**

After creating stories and giving them values using the evidence, one story with the highest score remains. However, using this score says nothing about the quality of the story, it only says which story is the best using the evidence at hand in this case. This means that it is not possible to say if this story is good or not. The determination of a story is good or not is done by the judge in the case in which this story will be presented.

- **Evidence was steering (only important evidence was given pointing towards these stories.)**

For this case study an analyst made a selection of evidence from the real case. This means that the analyst selected the evidence, which was important for the investigation and workable for one person. This does mean however that a lot of irrelevant evidence and thus statements were not used in the case study. This makes the case study workable for one person but makes the case more biased towards the result making it more biased towards the result the police had in this case.

- **Lack of steering for the police.**

The police needs steering points for their investigation. The hybrid theory does not mention how this should be handled. However, step seven does present the story scheme of all the stories made by the evidence which is presented in the chronolist and which is further processed in the steps before. Using the 7w's from the story schemes might help to show which elements of the story are still needed in order to create complete stories.

- **Police opinion about the hybrid theory in general and the hybrid theory method after the execution.**

The police was interested but skeptical about how the hybrid theory would perform in real-life. They thought the "messy" practice would not fit the theoretical hybrid theory. The hybrid theory so far had only been applied in theoretical cases. The police saw a main problem that the hybrid theory did not specify how information should be valued and how the filtering of information should be done. For example how the sorting through suspects should be done.

When the hybrid theory method was applied in the case study the police were a bit more enthusiastic. The method does give a nice oversight of how evidence became stories and why certain choices were made. However, without strong evidence the hybrid theory might get stuck on step three and eight. This does not have to mean that the method is not useful. When the whole method is gone through and many stories are still left, then the hybrid theory method can give some pointers on what to focus on. For example if there are a lot of stories because there are a lot of suspects left, then the investigation should focus on the elimination suspects. If there are many stories left because the murder weapon is unknown, then the investigation should focus on the weapon.

- **Technology lag**

Automation is difficult to perform at the police. Excel with query already crashes. The idea was to link everything to the chronolist so each person/place/ argument used in the following steps was supported by evidence. However, due to the hardware the analysts of the police use to do their daily work, it is not possible to execute bigger queries. Therefore, most of the steps are performed manually. This means that all the information from the chronolist is manually transferred to and processed for each step of the hybrid theory method. The information from the chronolist is also manually formed into stories. Maybe this is better since making linked lists from everything might enhance tunnel vision. The consideration to anonymize the data and then work on a better computer was present. However, the method and accompanying dashboard should be usable by analyst. This means that the choice was made to keep the program small so it can run on computers analysts use in their daily work.

4.3.2 Future research

- **Scoring**

To improve the hybrid theory method it is important to improve the scoring system used in step nine. The scoring system used in the hybrid theory method is ad-hoc and is not created with extensive research. A well-researched scoring system could improve the whole hybrid theory method. This scoring system should give the whole hybrid theory method a stronger reasoning supported with scores. The stories in step nine, for example, could be better compared if a scientifically supported scoring system is used. When this scoring system is created successfully, it can be applied to other steps of the hybrid theory method. An example of a scoring method could be a Bayesian scoring method.

- **live case**

Since in the case study the evidence was divided into two sections, evidence before the tipping point of the investigation and after the tipping point of the investigation, it is hard to determine where in the police investigation the hybrid theory would add value in practice. To find out in which stage of a police investigation the hybrid theory would prove to be useful, it is recommend that a live police investigation is followed using the hybrid theory. It would be possible then to see what kind of evidence is needed in order to make the hybrid theory add value and at which point of an investigation the hybrid theory would help an investigation. After this case study, it would also be possible to determine which information is needed in order to make the hybrid theory a useful tool.

- **cold cases**

After presenting the case study to the police, they indicated that the hybrid theory method might be interesting to apply on cold cases. The hybrid theory method could give new insights by redoing the case in the hybrid theory method. The hybrid theory method might give a better oversight by showing each step in the process. This might indicate what is missing of which lead is missed when the case was previously investigated.

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Appendix

Adam says he has a gun

Evidential gap

Adam has a gun

Adam is robbed by Tim

Tim is seen at the park

Adam goes to the park

Adam gets robbed by Tim

Adam shoots Tim with his pistol

Tim dies of shotwounds

Adam drives home

Tim's body is found

delarations made by adam at the police station.

Alfred sees Tim in the park

Telephone conversation between Adam and his Son where he says that he didn't let him rob him for the third time

Not literaly said that he was robbed, just that he did not let it happen the third time

Nobody saw Adam

Report of NFI: Tim died of shotwounds

Car like Adam's is seen

Alfred Testifies that he saw the victim lyiing in the park

Adam's car is seen on video

Report of the NFI :gun found in the house of Adam used to kill Tim
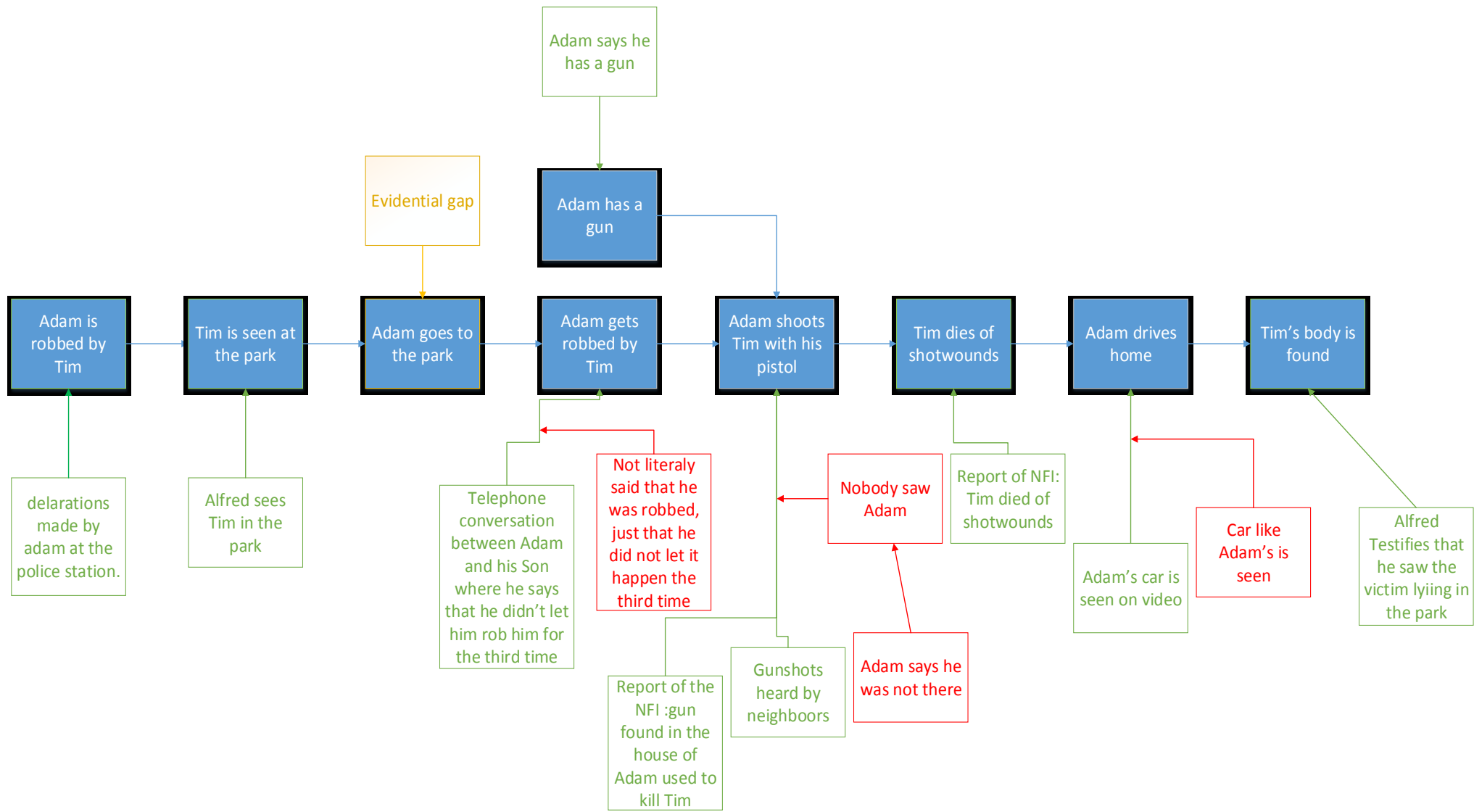
Gunshots heard by neighboors

Adam says he was not there

Figure 37: story one

Figure 38: Story two

Figure 39: story three

Create chronlist

Identify the victim

Find suspects
List people
Give roles
Exclude roles
List suspects

Define the crime scene

Determine cause of death and murder weapon

Categorize evidence

Create story schemes

Create stories

Final reasoning
Fill evidential gaps
Undercut stories

[else]

[one final story left]

Keep final story

CHRONOLIST
- time
- stated by
- stated about
- statement
- source

VICTIM
- name
- age
- nickname
- social milieu
- nationality
- gender

PEOPLE
- name

ROLE

SUSPECTS
- name
- gender
- relation to victim
- motives

CRIME SCENE
- location of the body
- flight routes
- cameras

MURDER WEAPON AND CAUSE OF DEATH
- weapon
- cause of death

ORGANIZED EVIDENCE
-evidence
- organization

STORY SCHEMES
- 7w's

STORIES
-event
-time
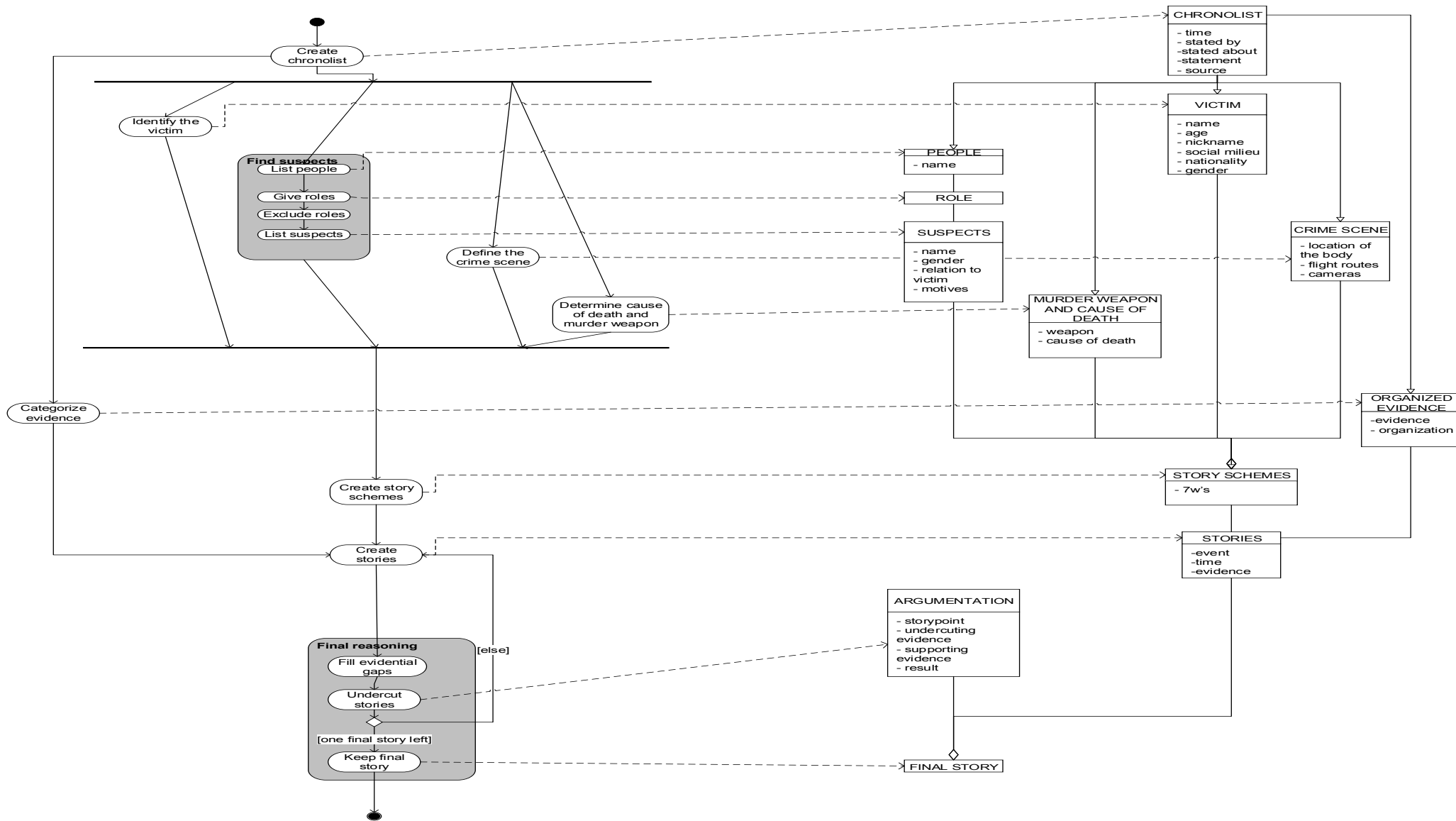-evidence

ARGUMENTATION
- storypoint
- undercuting evidence
- supporting evidence
- result

FINAL STORY

Figure 40:process delivery diagram