Anchored Narratives in Reasoning about Evidence

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Abstract. This paper concerns the reasoning with stories, evidence and generalisations in a legal context. We will make some notions from the existing Anchored Narratives theory more clear by making use of two formal techniques from AI, namely causal-abductive reasoning and default-style argumentation. We will propose a combination of these two formalisms which solves some of the problems of the causal-abductive approach.

1. Introduction

In matters of evidence, a judge, a juror and an investigating officer all have to reason from the evidence in a case to a conclusion and, particularly in the investigative phase, also vice versa. Often, the reasoner must not only apply the rules of law to the case facts, but he must also use commonsense knowledge about the world. In the case of a criminal investigation, the fact finder must check whether the case facts comply with the hypothesis he has in mind. In a complex case with much evidence, often different viewpoints must be considered and it is not always clear whether or not the accused is guilty (in a criminal case) or what direction a criminal investigation should take.

John Henry Wigmore was one of the first scholars who analysed reasoning with evidence and proof in a legal context [15]. Among other things, he developed a graphical notation for evidential arguments and their sources of doubt.. Based on Wigmore's work, Anderson, Twining, Tillers and Schum [1][10] have more recently discussed such topic as the logic of inferences about facts, the use of formal probabilistic methods in evaluating evidence and the visualisation of evidential arguments. In AI & Law, Bex et al. [4] formalised Wigmore's notation in a formal argumentation framework, using an approach with argumentation schemes. Finally, Walton [14] looked at reasoning with evidence from the standpoint of informal logic.

As an alternative to these argument-based approaches, psychologists have proposed a more holistic approach to legal reasoning with evidence, based on the notion of narrative, or story. For example, Bennet and Feldman [2] and Pennington and Hastie [8], argue that reasoning about evidence is most persuasive if it takes the form of constructing stories about what happened. Crombag et al. [5] have further developed this approach. According to their Anchored Narratives Theory (ANT)., the only viable way in which factual judicial decision making can proceed is by constructing stories and supporting, or "anchoring" them by common sense generalisations. This approach

has gained interest of others as well. For example, Anderson, Twining and Schum devote a chapter to stories in their last edition of Analysis of Evidence ([1], pp. 280), and Verheij [12] compares the anchored narratives approach with an argument based approach in. Thagard [9] has applied his connectionist model of abductive inference to the best explanation to legal cases, claiming that it provides a computational account of the story approach to legal evidence. Likewise, Keppens and Schafer [6] have applied model-based reasoning to automated support for the investigation of murder cases.

Despite this recent interest in the role of stories in evidential reasoning, an analytic account of the elements of a story and how it relates to generalisations and evidence is still lacking. Our aim in this paper is to clarify ANT in these two respects, making use of formal techniques from AI (& Law). We will propose to model stories as a causal-abductive theory and we will argue that these theories should be connected to the available evidence with argumentation. This gives rise to a distinction between two kinds of story anchoring, viz. internal and external anchoring. We will then illustrate our proposal in detail with an example also used by Crombag et al.

2. Anchored Narratives

In [5] and [13], Crombag, Van Koppen and Wagenaar both study empirically how judge in Dutch criminal cases decide on the facts and propose their ANT as a normative model. According to ANT, legal decisions have to be based on stories, which have to be anchored in common sense generalisations. In ANT, judges first determine the *quality* of the stories of the parties presented to them by the prosecution and the defence and then examine the *anchoring* of the stories using *common sense generalisations*, some of which can be considered as strictly true, for example 'a person cannot be in two places at the same moment', while other ones can be doubted, for example 'Witnesses under oath usually speak the truth'. The questions are whether the implicit generalisations that the story itself invokes are safe to believe and whether the generalisations which allow us to reason from the evidence to the story are safe to believe. We now examine these two issues in more detail.

2.1. The quality of the story

When determining the quality of a story, Crombag et al. draw on work by Bennet and Feldman [2] and Pennington and Hastie [8]. The core of a good story about a criminal case is an action, namely the criminal offence, and its consequences. A good story tells how the circumstances brought the actor in such a psychological and/or physical state that he had a motive and an opportunity to commit the criminal offence.

Pennington and Hastie [8] proposed the causal story structure in Figure 1 ,   as a template for stories about intentional actions and their consequences. Crombag et al. adopted this structure since it captures the elements that have to be proven in a standard crime: who is the offender (the actor in the story), what did he do (the *actions*) and did he act intentionally or recklessly (the *psychological states/goals*). In ANT, a story's quality is measured in terms of how well it fits the story template.
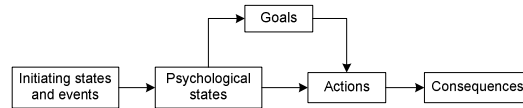
Figure 1: Pennington and Hastie's story structure

This criterion is also discussed by Pennington and Hastie. However, they also discuss two other criteria not discussed in ANT, namely *coverage* and *consistency*. A story's coverage is the extent to which the story accounts for the evidence presented, while a story is consistent to the extent that it does not contradict itself or any of the evidence. Pennington and Hastie also give a fourth principle, namely *plausibility*, which says that a story is plausible to the extent that it corresponds to the decision maker's knowledge of the world. This last principle corresponds to what Crombag et al. mean by the anchoring of the story so we will discuss it in section 2.2.

2.2. Anchoring the story

In addition to being good, stories must also be anchored in common sense knowledge of the world around us. How this anchoring works is best explained through an example, namely the King case ([5], pp. 460-463), a relatively simple case about an alleged burglary. The prosecution presents the following story:

```
    On the 18th of November, Andrew King climbs over the fence of the
backyard of the Zomerdijk family with the intention to look if there is
something interesting for him in the family's house. Through this yard he
walks to the door that offers entry into the bedroom of the 5-year-old
son of the family. The door is not closed, so King opens it and enters
the bedroom to see if there is anything of interest in the house. Because
it is dark, King does not see the toy lying on the floor. King hits the
toy, causing it to make a sound which causes the dog to give tongue. King
hears the dog and runs outside, closing the door behind him. Mr.
Zomerdijk hears the toy and the dog. He goes to the bedroom and sees King
running away through the closed garden door. He shouts "there is a
burglar, come and help me!" and runs into the garden after King. King,
who wants to pretend he is lost, does not run away. In spite of this,
Zomerdijk jumps on King and, aided by his brother, who is visiting the
Zomerdijk family, molests King.
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This is a fairly plausible story because it appeals to certain implicit generalisations that seem obvious when made explicit; for example, King must have been the person who hit the toy if the rest of the family and the visitors were in the living room, and he was probably up to no good anyway. Why else did he enter the garden in the first place, and why did he run away when Mr. Zomerdijk appeared in the bedroom?

In order to evaluate the story, two types of generalisations are relevant. Firstly, the causal links *within* the story must be justified by plausible causal generalisations, such as "If a sound is heard in the bedroom and all the people you know are in the living room, there must be someone else in the bedroom" and "if someone runs away through the garden he was probably up to no good". Secondly, the story must be linked to the available evidence by plausible evidential generalisations, such as "witnesses usually speak the truth". In the King case, the prosecution's story is mainly based on the testimonies given by Mr. and Mrs. Zomerdijk and their visitors. If the decision-maker believes the prosecutor's story, he accepts the generalisation that "witnesses usually

speak the truth". Alternatively, the decision maker can think that the witnesses want to protect each other. This is an exception to the generalisations that witnesses usually speak the truth, and if the decision maker has a good reason to believe that the witnesses want to protect each other, he will no longer believe that they speak the truth.

In ANT it is discussed in detail how generalisations can be analysed in this way and decision makers are urged to make the common sense knowledge they use to come to their decision explicit, so that the ultimate decision is better motivated and not based on dubious generalisations. However, the details of what part the generalisations play in a story are left untreated. Also, the exact interplay between the evidence, a story and the generalisations connecting these two is not elaborated upon.

3. Logical tools for analysing the Anchored Narratives theory

From the discussion so far it has turned out that, while the ANT seems basically sound, no analytical account of how the interplay between stories, generalisations and evidence takes place has yet been provided. Our first aim therefore is to determine the exact role generalisations play in reasoning with stories and evidence. Our second aim is to give evidence a more prominent place in the evaluation of stories by using the notions of coverage and consistency.

In our analysis we will use some existing logical tools, and propose some adjustments to these tools. In section 3.1 we will model stories as a causal network that can be used in abductive inference to the best explanation. Section 3.2 introduces notions from argumentation logics, which are used to connect stories to the pieces of evidence in the case. Because of space limitations our notation will be largely semiformal but they easily map onto well-known formalisms.

3.1. Stories as a causal networks

Before investigating how generalisations can be analysed, we will first have to say something about the formal structure of stories and the role they play in the anchoring process. An underlying principle in all above-discussed approaches to stories is the causality between the states and events in a story. Our proposal is therefore to model stories as causal networks. Figure 2 displays the King story as a causal network.
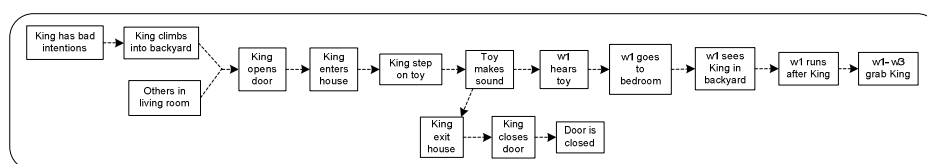

Figure 2: the King story as a causal network

Note that by modelling stories in this way, some information is lost. For example, the different categories proposed in Pennington and Hastie's template are no longer part of the theory. However, we will argue that this way of modelling has its advantages and leave other aspects of stories for future research.

A causal network can be used as an *abductive theory*, in which observations are *explained* by hypothesised events or states through abductive reasoning, or 'inference

to the best explanation' (IBE). In AI many formal and computational accounts of IBE are available. However, the following simplified account covers their main elements and suffices for present purposes.

A *causal theory* T is a set of implications of the form c_1 & ... & $c_n \Rightarrow_c e$, where c_1 ... c_n are literals, standing for causes that in conjunction produce an effect e, which also is a literal. Causal rules can be chained, since effects can in turn be causes of other effects. In addition there is a consistent set O of *observations* (a set of literals), which are to be explained by T. More precisely, an observation $o \in O$ is explained by T if for some set $H \subseteq T$ of *hypotheses* it holds that

- $H \cup T \vDash o$; and
- $H \cup T$ is consistent.

In AI usually only subset-minimal sets of hypotheses are considered. Also, in AI it is usually required that a hypothesis explains all observations in O but this condition is unrealistic if the correctness and completeness of the causal theory is not guaranteed, (cf. [9]), as is often the case in legal evidential reasoning.

The IBE approach nicely captures the explanatory role of evidential stories. However, it abstracts from their internal anchoring with causal generalisations; the theory T contains causal rules, but there is no possibility to reason about these rules. IBE also has a problem in dealing with witness testimonies as evidence. It requires that witness testimonies are regarded as caused by other things. For instance, the truth of what is testified is regarded as causing the testimony. Of course, since witnesses do not always speak the truth, other possible causes of a testimony must also be modelled, such as a motive to lie, or circumstances that can cause flawed perception or memory. So causal rules like the following ones should also be included:

```
p ⇒c w said "p"
w has reason to lie about p  ⇒c w said "p"
w hallucinated and thought he saw p ⇒c w said "p"
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However, this creates the following problem. What we want to know is how the theory explains the observation that *w said "p"*. In a causal theory with the above three rules, the testimony can be explained in three ways: it can be explained in the 'normal' way by supposing that the witness speaks the truth, i.e. by *p*, but it can also be explained by supposing that *w has reason to lie about p* and by supposing that *w hallucinated and thought he saw p*. Moreover, these explanations fair equally well on coverage and consistency so there is no obvious way to prefer the 'normal' explanation. In this way, the abductive approach fails to capture that witness testimonies are usually true; *w has reason to lie about p* and *w hallucinated and thought he saw p* should not be 'abducibles': they are exceptions to a default rule and should therefore be assumed false if there is no evidence to the contrary.

Our solution to this problem is to invert *causal* generalisations in which the antecedent is the usual cause of the consequent into *evidential* generalisations (this terminology is due to Pearl (1998) [7]). These evidential generalisations are then used to connect nodes in the story structure to evidence outside that structure; this connection is formalised as argumentation, in particular, default reasoning and reasoning with argumentation schemes.

3.2. Evidence and arguments

We assume a logic in which applications of deductive and/or defeasible inferences can be chained into tree-structured arguments. Associated with a defeasible inference is a generalisation that acts as the *warrant* (cf. Toulmin [11]) for the inference. Because we want to be able to change generalisations, they are modelled as additional premises to an argument and are subject to a defeasible modus ponens inference rule which allows for exceptions. We assume that the logic respects Pearl's c-e rules [7], that is, it is not allowed to apply an evidential generalisation to a proposition that has been inferred by application of a causal rule.

A defeasible argument can be attacked in two ways. It can be *rebutted* with an argument for the opposite conclusion, while it can be *undercut* with an argument why a generalisation does not apply in the given circumstances. Arguments can be either *justified*, which means that they are not attacked by other justified arguments that are stronger, or *overruled*, which means that they are attacked by one or more other stronger arguments that are justified, or *defensible*, which means that they are neither justified nor overruled.

In this paper, causal networks, arguments and inferences are represented through figures (see Figure 3 for examples). This is a semi-formal way of representing them, but a formal translation into well-known formalisms is straightforward.
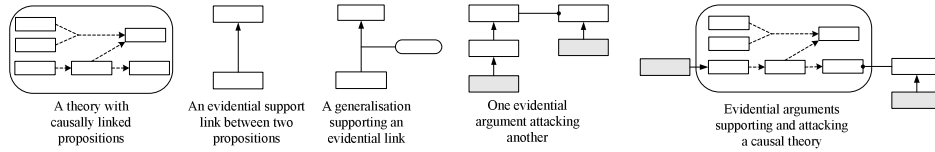

| A theory with causally linked propositions | An evidential support link between two propositions | A generalisation supporting an evidential link | One evidential argument attacking another | Evidential arguments supporting and attacking a causal theory |

Figure 3: stories, arguments and generalisations

3.3. Combining causal and evidential reasoning

We now discuss how the abductive and argumentation formalisms can be combined. The idea is that by providing stories and explanations for certain facts, the parties build a causal network. By telling the main story, the prosecution provides us with the causal network as seen in Figure 2. If King gives an alternative explanation for the fact that he was in the yard, for example, because he was lost, he adds a node *King is lost* to the network, which is linked to *King climbs in into backyard* by a causal link. King can also tell a different story explaining, for example, why the toy made a sound. We will explore this in further detail in section 4. In addition to giving (alternative) explanations for facts, it is also possible to support or defeat facts in the story with evidence through evidential arguments. Important here is that only propositions supported by evidence have to be explained; only if a proposition in the causal network is supported by a justified argument, it becomes a member of the set *O*. It is also possible that a proposition in the causal network is defeated by an evidential argument; in this case, the proposition should ideally *not* be explained by $H \cup T$.

With such a causal network connected to evidence, generalisations can be critically examined in two different ways. The first is by refining it, which adds a new condition, which must also be proven (cf. [3]). The second way is to provide evidence that there is an exception to the generalisation.. If the decision maker thinks that a certain generalisation is implausible, he can change it into a refined version. For example, the

generalisation "**if** a person has the opportunity to enter a house (where he does not live), **then** he will do so" can be refined into "**if** a person has the opportunity to enter a house (where he does not live) **and** he has bad intentions, **then** he will do so". If the decision maker instead believes a generalisation but thinks that in the case at hand an exception to the default generalisation applies, then he can also attack the generalisation. For example, if one of the three witnesses (Mr. Zomerdijk, his wife and his brother) explicitly stated that they wanted to protect each other, then the inference `the witnesses testify that they were in the living room ⇒ₑ the three witnesses were in the living room`, which is based on the generalisation "witnesses usually speak the truth", is undercut by an exception..

4. Anchoring the King story: a worked out example

In this section we illustrate the combination of causal and evidential reasoning given in section 3 with an account of the King case. In addition to the story from section 2.2 (see Figure 2), we also have a number of testimonies. King testified that he climbed over a wall to get into the backyard. Mr. Zomerdijk, witness 1 (w1) from here on, testified the following: "I was in the living room with my wife and my brother, and suddenly I heard a toy making a sound in the bedroom. I went to the bedroom and, through the closed door, I saw a man, who I now know to be Andrew King, running away from the house in the backyard. I went outside and ran after the man. My brother also came to help me and we grabbed the man". Mr. Zomerdijk's brother (w2), testified that he was in the living room and that suddenly, Mr. Zomerdijk stood up and went to the bedroom. When the brother went after him a few seconds later, he saw a man running in the garden and grabbed him. Mrs. Zomerdijk said she was in the living room with her husband and brother-in-law. This evidence can be used to support some of the propositions in the story, viz.:
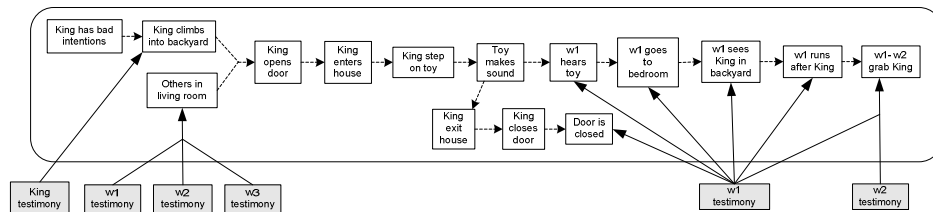

Figure 4: the main King story and its supporting evidence

According to section 3.3, the observations that have to be explained by the causal theory are the propositions in the story that follow from undefeated evidential arguments, in this case {*King climbs into backyard*, *others in living room*, *w1 hears toy*, *w1 goes to bedroom*, *w1 sees King*, *w1- w2 grab King*, *door is closed*}. If we take a hypothesis H_1 = {*King has bad intentions*, *others in living room*}, then all the observations are explained by $H_1 \cup T$.

We next consider the evidential links between the evidence and the network. If we accept the link between the three testimonies and *others in the living room*, we implicitly accept the generalisation "if three witnesses testify that "*p*", then usually *p* is

true". In section 3.3 we saw that one way to attack this generalisation is to say that "if three witnesses try to protect each other, then they will not speak the truth", viz.:
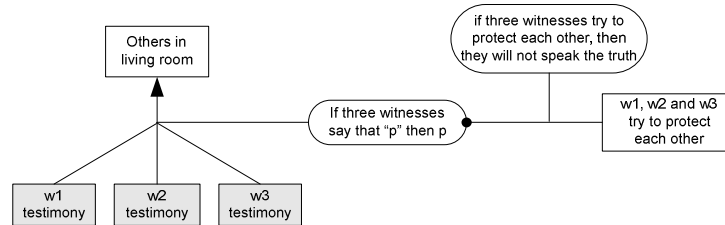

Figure 5: a generalisation is attacked

However, in this case the decision maker does not have a direct reason to believe that the witnesses tried to protect each other, so the generalisation is not defeated and the argument for *other in living room* is justified.

The causal generalisations within the story can also be analysed. A dubious causal link in the story is the one between *King climbs into backyard*, *others in living room* and *King opens door*. This link stands for the (more abstract) generalisation "if a person has the opportunity to enter a house (where he does not live), he will do so". This generalisation arguably is too general to be acceptable as an anchor; not everybody who has the opportunity enters another person's house. One possible remedy is to refine the generalisation, for example, into "if a person has the opportunity to enter a house (where he does not live) and he has bad intentions, he will do so". The resulting generalisation is more acceptable as an anchor.. Figure 6 shows a zoomed-in part of the causal network with the new generalisations and links added.
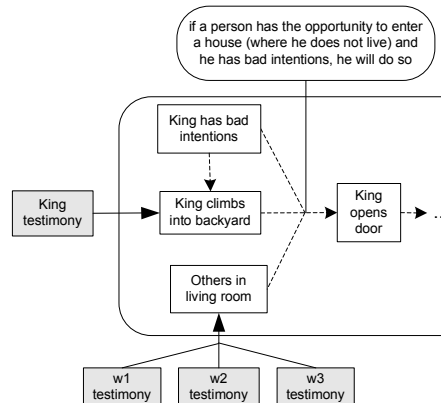

Figure 6: part of the King network with added links and generalisations

King has his own explanation for the fact that the toy made a sound; he claims that the wind blew open the door, hit the toy (which caused it to make a sound) and then blew the door shut again. This explanation extends the causal network of Figure 4 with the following rules:

```
wind opens door ⇒c wind hits toy; wind hits toy ⇒c toy makes sound;
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wind opens door ⇒c wind closes door; wind closes door ⇒c door closed
```

This extension of the theory adds a new explanation for the propositions *toy makes sound* and *door is closed*. However, assume next that none of the witnesses heard a bang just after the sound of the toy and assume also that normally, when the wind blows a door shut, there is a loud bang. With this information, two things can be done. First, the causal theory can be further expanded with the rule `wind closes door ⇒c loud bang`. Next, an argument can be built that defeats *loud bang* by first inferring *none of the witnesses heard a loud bang* from the testimonies, and then inferring *there was no loud bang* from this. Figure 7 shows the updated causal network together with the extra argument. Because of space limitations, only part of the updated causal theory is shown in Figure 7.
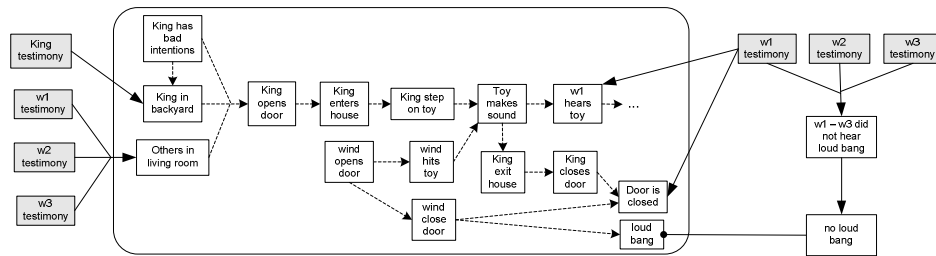

Figure 7: the causal theory after King's explanation is added

Hypothesis H_1 still explains all the observations; King's hypothesis, H_2, only contains the proposition *wind opens door*. H_2 also explains the facts that the toy made a sound and that the door was closed; however, it does not explain that King was in the backyard. If King wants to explain this fact, he either has to accept that he had bad intentions or must give an alternative explanation.

Another problem with H_2 is that it explains *loud bang*, while there is an undefeated evidential argument for the opposite. So applying Pennington and Hastie's covering and consistency conditions, it can be argued that the prosecution's explanation covers more (more observations are explained by H_1 than by H_2, and H_1 is more consistent (because it does not explain propositions that are defeated).

5. Conclusions and future research

In conclusion, we have made the following contributions. First we have argued for a combination of a causal-abductive and a default-style argumentation modelling of evidential reasoning, thus avoiding a problem with reasoning about witness testimonies in a purely causal-abductive approach. In result, we have seen that there are two different kinds of links that have to be supported by safe generalisations: the causal links that are part of the story itself and the evidential links that are part of the arguments that connect the evidence to the story. Also, we have shown that there are two ways of analysing generalisations: if the generalisation itself is dubious, then it can be refined while if the generalisation is safe but in the case at hand a possible exception applies, then it can be attacked. Thus we have refined the ANT notion of anchoring in two important ways.

However, our approach still leaves some questions unanswered. Firstly, the exact details of how a hypothesis explains a set of observations and how hypotheses should be compared have not been discussed. For example, in this paper we have assumed that all observations are equally important but there may be different categories of observations, namely some that have to be explained by the hypothesis and some that add to the explaining hypothesis' believability but do not necessarily have to be explained. Another important question is: when can one hypothesis be considered better than another? For example, is coverage more important than consistency?

Secondly, the ideas proposed in this paper are just a start in the precise analysis of the role of stories in legal reasoning. For example, the exact role of templates like the one proposed by Pennington and Hastie for assessing the quality of a story as a whole is still unclear.

Acknowledgements

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