

Evaluating cases in legal disputes as rival theories

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Abstract. In this paper we propose to draw a link from the quantitative notion of coherence, previously used to evaluate rival scientific theories, to legal reasoning. We evaluate the story of the plaintiff and the defendant in a legal case as rival theories by measuring how well they cohere when accounting for the evidence. We show that this gives rise to a formalized comparison between rival cases that account for the same set of evidence, and provide possible explanations as to why judgements may favour one side over the other. We illustrate our approach by applying it to a known legal dispute.

Key words: legal argument, legal justification, theory construction, coherence

1 Introduction

In legal disputes each side present their case before the court, outlining the issues, positions, and arguments taken with respect to the issues. The “story” is supported by evidence, which sometimes is explicitly sought by the judge as burden of proof. Each side must explain how the evidence fits their story, though there may be elements of their story that for some reason cannot be verified by evidence or empirical testing.

Similarly in the philosophy of science, rival, possibly incompatible scientific theories must also account for all observations, but empirical testing cannot be used to differentiate or rank the theories, as they make the same empirical claims. One measure to evaluate the theories is how *coherent* the theory is in accounting for observations.

We propose to draw parallels from this to legal reasoning, where we view the cases of the plaintiff and the defendant in a legal dispute as rival theories, and evaluate the cases by measuring how coherent the stories are in their account for the evidence. Intuitively, just as a good scientific theory uses only a few credible postulates to explain a large body of evidence. This provides an alternative view on how the cases can be evaluated and decided, and provide a possible

explanations as to why judgements may favour one side over the other, in a formal and structural manner.

The notion of coherence in legal justification is well explored by Hage [3] and Amaya [1]. Equally, there is abundant literature on abductive reasoning with respect to the evidence and the burden of proof by Prakken et al. and Satoh et al. [9, 10]. However, the existing literature on coherence is mostly concerned with how a decision can cohere with existing law and cases, and whereas we are interested the overall picture of how the “story” of the plaintiff/defendant coheres with the evidence.

In this paper we introduce the notion of *coherence* as proposed by Kwok et al. [4, 5] for evaluating scientific theories. We then propose a possible scheme based on the previous work by Kwok et al. [4, 5] for evaluating the coherence of cases in a legal dispute. This is followed by illustrating our approach with an example of applying our theory to an actual legal dispute previously formalized by Prakken [7]. Finally, we discuss what is implied by our “coherent” theories in a legal dispute and possible future directions that this work may take.

2 Coherence of theories

Traditionally in the philosophy of science, coherence has always been a criterion in evaluating the quality of scientific theories. The extent of coherence of a theory depends on informal, qualitative notions such as “brevity”, “predictive scope” and “tightness of coupling” of components of the theory. Kwok et al. [4] proposed a quantitative measure of coherence based on the average utilization of formulas in accounting for observations. Their later work, Kwok et al. [5], better mirrored scientific practice by introducing input and output sets. The proposed measure facilitates the testing of theories with experiments that have varying inputs and outputs, where all bases of theories are clauses. In this section we summarize the approach developed by Kwok et al. [5].

Definition 1 (Support Sets) *Given an input set I , an output set O , a subset of the theory T being Γ . Then, Γ is a I -relative support set of O if:*

1. $\Gamma \wedge I \models O$ and
2. Γ is minimal (wrt set inclusion).

Support sets are the building blocks of the coherence measure. They are the formulas that accounts for a particular observation for a given input. We denote $S(T, I, O)$ to be the family of all I -relative support sets for O .

Definition 2 (Utility of a formula) *Given an input set I , an output set O , a theory T and a formula $\alpha \in T$, its utility is:*

$$U(\alpha, T, I, O) = \frac{|\{\Gamma : \alpha \in \Gamma \text{ and } \Gamma \in S(T, I, O)\}|}{|S(T, I, O)|} \quad \text{if } S(T, I, O) \neq \emptyset$$

The support sets give rise to the definition of the utility of a formula of the theory. Informally, this is the relative frequency of occurrence of formula α in the support sets of O . This reflects the contribution of α in T to account for O .

Definition 3 (Coherence of a Theory) *The coherence of a theory T with formulas $\{\alpha_1, \dots, \alpha_n\}$ with respect to input observations $\{I_1, \dots, I_m\}$ and output observations $\{O_1, \dots, O_m\}$ is:*

$$C(T, I, O) = \frac{1}{mn} \sum_{i=1}^n \sum_{j=1}^m U(\alpha_i, T, I_j, O_j)$$

The coherence of a theory is the average utility of the theory’s formulas in accounting for all the observations from possibly multiple experiments. This measure has been shown to demolish Craig’s trick by Craig [2], where empirical observations are simply added to the theory as exceptions. It showed such handling of exceptions results in the formulation of highly incoherent theories.

3 Evaluating legal cases

In this section, we draw a link between scientific disputes of rival theories to ordinary legal disputes between cases of the plaintiff and the defendant. We treat the “stories” given from both sides as rival theories, each can be tested against the evidence presented to the court. Just as scientific theories can be tested over multiple experiments, a case in a legal dispute can be tested by multiple pieces of evidence and testimonies. We evaluate the coherence of the case by measuring how well components of the case are used in accounting for the evidence and the testimonies. We assume that all the components of the sets mentioned in the following subsections are clauses.

3.1 Inputs

The presentation of evidence and testimonies can be viewed as experiments testing the theory, the input of the experiment are then: the relevant laws, the agreed state of affairs and the consequences that are necessary for the theory to entail the output.

An agreed state of affairs is a state of affairs that is presented by some participant of the trial, but is not contested by any other participant. It can thus be deemed that it can be regarded as a fact from which one may draw conclusions. Similarly, an agreed consequence is a consequence brought forth by a participant that is not contested. We relax the requirement of inputs to include laws and facts that are not used in deriving the output, as they do not affect the utility of any component of the theory and hence have no effect on measuring coherence.

3.2 Outputs

The outputs are the evidence and testimonies presented to the court. Many are sought by the court as *burden of proof*. They should be the consequences of the input plus the theory. That is, the “story” told by the plaintiff and the defendant must account for the output. i.e. why certain DNA is present on the crime scene, why witness X testify that A loaned equipment to B.

3.3 Theory

The theory being evaluated in the case of a legal dispute is the “story” that is told by one of the sides. It may contain several components to explain the evidence presented to the court, plus why the desired outcome holds for the plaintiff/defendant. Therefore, the two “stories” from the plaintiff and the defendant are seen as rival theories that account for the same set of evidence.

3.4 Support sets and coherence

The I -relative support set for O is a subset of the theory that accounts for a particular evidence O_i given input I_i . The relative frequency of a component appearing in the support sets give rise to the utility of the component, where coherence is measured as the average utility of the components over all evidence. Intuitively, the support set for a given piece of evidence is how the plaintiff/defendant explain that piece of evidence with respect to the accepted facts and relevant law presented before the court. The coherence of the theory measures how well the overall “story” from the plaintiff/defendant explains all the evidence.

4 Example

As an example of how our notion of coherence can be applied in order to evaluate rival cases between plaintiff and defendant, we apply it to a legal dispute first formalized by Prakken [7]. While we simplify the cases to two sets of clauses, we attempt to stay consistent with as much of the previously done formalization as possible, differing only when our notion of coherence forces us to do so.

4.1 The dispute

The example used by Prakken [7] is a Dutch civil case from 1978, concerning the ownership of a moveable good, a large tent. The owner of the tent, Mr. van der Velde, put the tent out for sale at the price of 850 Gulden (approx. 380 Euro). Mr. Nieborg, who was a friend of Mr. van der Velde, said that he was interested in buying the tent but could not afford it. Mr. van der Velde still made the tent available to Mr. Nieborg, who in return helped Mr. van der Velde to paint his

house. Mrs. Nieborg also helped Mrs. van der Velde with her domestic work for some time.

Later, Mr. Nieborg claimed that he and his wife had performed enough work for Mr. van der Velde to pay for the cost of the tent, thus implicitly claiming that he now had become the legitimate owner of the tent. This angered Mr. van der Velde since he saw the work performed by Mr. and Mrs. Nieborg as an expression of gratitude for allowing them to use the tent. He immediately demanded that Mr. Nieborg would return the tent. When his demands were not met, Mr. van der Velde, with assistance, threw Mr. Nieborg’s son, which was the person currently occupying it, out of the tent and took possession of it.

Some time later, Mr. van der Velde sold the tent to the defendant, Mr. van der Weg. Mr. van der Weg paid for the tent by performing work, which was similar to the work performed earlier by Mr. and Mrs. Nieborg, for Mr. van der Velde. Mr. Nieborg took the case to court within a period of time which was less than three years after the events of the repossession of the tent performed by Mr. van der Velde, a fact that should be noted due to implications in regard to Dutch law.

We present the cases of both Mr. Nieborg and Mr. van der Weg in clausal form. In order to make our clauses as brief as possible to the comfort of the reader, we apply the abbreviations seen in table 1. We also abbreviate the relevant points in time as seen in table 2. Both sets of abbreviations conforms to those used by Prakken [7]. In running text we will still use the full names and points in time.

| Surname | Abbreviation | Role |
|-------------------|--------------|-----------|
| Mr. Nieborg | N | Plaintiff |
| Mr. van der Weg | vdW | Defendant |
| Mr. van der Velde | vdV | Witness |
| Mr. Sluis | S | Witness |
| Mr. Galtema | G | Witness |

Table 1. Abbreviations for the participants of the trial

| Point in time | Event |
|---------------|---------------------------|
| t_1 | N held the tent |
| t_2 | N no longer held the tent |
| t_3 | Time of the trial |

Table 2. Abbreviations for the points in time relevant to the trial

4.2 Inputs - relevant laws, agreed state of affairs and consequences

We will in this section frequently refer to the relevant laws, agreed state of affairs and consequences in clausal form. They are the inputs of the respective theories for deriving outputs. The clauses are partially those found in Prakken [7], but also some additions. One difference to Prakken [7] is that we only consider the law, states of affairs and consequences that are relevant to the final judgement. This difference is due to our focus on the final judgement rather than the process of the trial itself, thus we can disregard the general usage of a law that is later refuted in favour of a more particular one. We will point out these special cases out when presenting the clauses. All formalized law, is law that is valid at the time of the trial. Also, just as in Prakken [7] we do not motivate the notion of persistence of ownership that Mr. Nieborg implicitly uses to justify that he indeed is still the owner of the tent at the time of the trial.

$$\text{Hold}(N, \text{Tent}, t_2) \quad (1)$$

$$\text{Hold}(vdW, \text{Tent}, t_3) \quad (2)$$

The first two clauses, 1 and 2, concerns the holder of the tent at different times. Clause 1, that Mr. Nieborg held the tent at the time it was taken from him. Clause 2, that Mr. van der Weg now holds the tent.

$$\text{Loan}(x, y) \rightarrow \text{TestimonyLoan}(z, x, y) \wedge (x \neq z) \quad (3)$$

$$\text{FalseTestimonyLoan}(x) \rightarrow \text{TestimonyLoan}(x, y, z) \wedge (x \neq y) \quad (4)$$

$$\text{Violence}(x, y) \rightarrow \text{TestimonyViolence}(z, x, y) \wedge (y \neq z) \quad (5)$$

$$\text{FalseTestimonyViolence}(x) \rightarrow \text{TestimonyViolence}(x, y, z) \wedge (x \neq z) \quad (6)$$

The next set of clauses, clause 3 to clause 6, lays forth the logic of testimonies, it should be noted that we assume a simple notion of lying to simplify our set of clauses. It should also be noted that we do not use any temporal components as seen in the previous clauses 1 and 2, the reasoning behind this is that the testimonies and events for our particular case does not need any temporal components due to them only occurring once. Just like the two preceding two clauses, this set of four clauses can not be refuted logically and has to be accepted by all parties.

Clause 3 and 5 simply states that if a person x borrowed item y or violence was inflicted by a person x towards person y , then person z can deliver a testimony of these events. Clause 4 and 6 provides an alternate mode for explaining each testimony, if the witness is lying, then his/her action would give rise to the same testimony.

$$\text{Hold}(x, y, t) \wedge \neg \text{Loan}(x, y) \rightarrow \text{Posses}(x, y, t) \quad (7)$$

Clause 7 is a formalization of Dutch law 590 BW. The loan condition is a simplification of the actual text that states that the holder may not be holding it for another person, this change is made to make the clause simpler since holding

the item can be derived from a loan in our specific case. The loan condition is an exception added to the original law 590 BW that lacks this condition, but since for our case the loan condition is relevant to the interpretation of the law and the judgement, it is added to our clause. This constraint makes it possible to disregard the notion of precedence by Prakken [7] and is justified by us only observing the judgement.

$$Posses(x, y, t) \rightarrow GoodFaith(x, y, t) \quad (8)$$

$$\begin{aligned} & Posses(x, y, t) \wedge GoodFaith(x, y, t) \wedge Owner(z, y, t') \wedge (x \neq z) \\ & \wedge InvoluntaryLoss(z, y, t') \wedge (t' - t) < 3 \text{ years} \\ & \rightarrow \neg Owner(x, y, t) \end{aligned} \quad (9)$$

Clause 8 is a formalization of Dutch law 589 BW which states that a possessor is presumed to be a possessor of good faith. Clause 9 is a formalization of Dutch law 2014 BW regarding possession of a good, with the exception that x can not be the owner of y if it has occurred an involuntary loss at a time t' from a previous owner z , then an event which has to have occurred within 3 years from the current time t .

4.3 Evidence presented

The following is indisputable evidence that all parties must account for, either with their own theory or by calling upon law, accepted states of affairs or consequences as presented in section 4.2. Each piece of indisputable evidence will form a separate subset of observation set O .

$$O_1 = TestimonyLoan(vdV, N, Tent) \quad (10)$$

$$O_2 = TestimonyLoan(G, N, Tent) \quad (11)$$

$$O_3 = TestimonyLoan(S, N, Tent) \quad (12)$$

$$O_4 = TestimonyViolence(vdV, vdV, N) \quad (13)$$

$$O_5 = TestimonyViolence(G, vdV, N) \quad (14)$$

$$O_6 = TestimonyViolence(S, vdV, N) \quad (15)$$

The members of the observation set O , described in clause 10 to 15, are all the testimonies delivered to the court. That the testimonies took place is irrefutable, but them taking place has to be explained by each theory presented in section 4.4 and 4.5.

To simplify our clauses we have taken the liberty of stating that the testimonies of violence supported violence towards Mr. Nieborg. In reality the involved party was Mr. Nieborg's son. We have also done the same regarding the

testimony of the tent being a loan, what was presented in reality was that Mr. Nieborg expressed a gratitude to the witnesses for being able to hold the tent for a limited time. As described by Prakken [7] the first counts as violence towards Mr. Nieborg in the case of legally proving involuntary loss and the expression of gratitude witnessed by the three witnesses lead to the event to be perceived as loan by the witnesses. We have simply left out these conclusions and replaced it with the result relevant to the judgement.

4.4 The plaintiff's case

To make a case both parties need to construct an input set by using the clauses from section 4.2 and produce a theory on how to explain each set of evidence from section 4.3. A theory may consist of any clauses, as long as it is minimal and provides evidence for every subset of O using it's respective subset of I .

$$T_{P1} = \text{Violence}(vdV, N, t_2) \quad (16)$$

$$T_{P2} = \text{FalseTestimonyLoan}(vdV) \quad (17)$$

$$T_{P3} = \text{FalseTestimonyLoan}(G) \quad (18)$$

$$T_{P4} = \text{FalseTestimonyLoan}(S) \quad (19)$$

$$T_{P5} = \neg \text{Loan}(N, Tent) \quad (20)$$

The first clause of the plaintiff's theory, clause 16, is a simple acceptance of the violent events at t_2 since this works in his favour. Although he is soon forced to add clauses 17 to 19 since he is unwilling to accept that his work was an expression of gratitude, which was how it was perceived by the witnesses. Not calling the testimonies false would render it impossible for him to claim previous possession, using 590 BW with its special case (clause 7) and 589 BW (clause 8). Thus being able to revoke the current hold of the tent by van der Weg using 2014 BW (clause 9) with its exception which is his own goal and his theory must account for. Clause 20 is included since it is a requirement for him to be able to use 2014 BW (clause 9) with the special case applied.

$$I_{P1} = \{\text{FalseTestimonyLoan}(x) \rightarrow \text{TestimonyLoan}(x, y, z) \wedge (x \neq y)\} \quad (21)$$

$$I_{P2} = \{\text{FalseTestimonyLoan}(x) \rightarrow \text{TestimonyLoan}(x, y, z) \wedge (x \neq y)\} \quad (22)$$

$$I_{P3} = \{\text{FalseTestimonyLoan}(x) \rightarrow \text{TestimonyLoan}(x, y, z) \wedge (x \neq y)\} \quad (23)$$

$$I_{P4} = \{\text{Violence}(x, y) \rightarrow \text{TestimonyViolence}(z, x, y) \wedge (y \neq z)\} \quad (24)$$

$$I_{P5} = \{\text{Violence}(x, y) \rightarrow \text{TestimonyViolence}(z, x, y) \wedge (y \neq z)\} \quad (25)$$

$$I_{P6} = \{\text{Violence}(x, y) \rightarrow \text{TestimonyViolence}(z, x, y) \wedge (y \neq z)\} \quad (26)$$

For his set I_P the plaintiff alternates between clause 4 regarding lies and clause 5 that implies that the testimonies are accurate. This in combination with his theory T_P is enough to prove all members of O .

4.5 The defendant's case

The defendant's case is very similar to that of the plaintiff's that we presented in section 4.4. But the minute differences will have effects on how it interacts with our theory of coherence.

$$T_{D1} = \text{Violence}(vdV, N, t_2) \quad (27)$$

$$T_{D2} = \text{Loan}(N, Tent) \quad (28)$$

In order to fulfil his goal of ownership the defendant simply has to assume that the testimonies regarding the loan are accurate, as is done in clause 28. This will enable him to thwart any attempts by the plaintiff to claim ownership using 2014 BW (clause 9) with its exception, since 590 BW with its exception (clause 7) would be impossible to use if the plaintiff held the tent as a loan.

The defendant has no need to discredit the violent events since they are neutral towards his goal of ownership when interacting with the laws contained in *I*. This is done by taking the same step of concurring with the violent events as the plaintiff did in clause 16 with the defendant's clause 27.

$$I_{D1} = \{\text{Loan}(x, y) \rightarrow \text{TestimonyLoan}(z, x, y) \wedge (x \neq z)\} \quad (29)$$

$$I_{D2} = \{\text{Loan}(x, y) \rightarrow \text{TestimonyLoan}(z, x, y) \wedge (x \neq z)\} \quad (30)$$

$$I_{D3} = \{\text{Loan}(x, y) \rightarrow \text{TestimonyLoan}(z, x, y) \wedge (x \neq z)\} \quad (31)$$

$$I_{D4} = \{\text{Violence}(x, y) \rightarrow \text{TestimonyViolence}(z, x, y) \wedge (y \neq z)\} \quad (32)$$

$$I_{D5} = \{\text{Violence}(x, y) \rightarrow \text{TestimonyViolence}(z, x, y) \wedge (y \neq z)\} \quad (33)$$

$$I_{D6} = \{\text{Violence}(x, y) \rightarrow \text{TestimonyViolence}(z, x, y) \wedge (y \neq z)\} \quad (34)$$

Just like the plaintiff, the defendant alternates between two clauses, in this case clause 5 and 3, both implying that the testimonies of the witnesses are the indications of a loan and a violent event taking place.

4.6 Calculation of coherence

We will now proceed to calculating the coherence for the plaintiff and defendant using our measure of coherence introduced in section 3.

For the six observations $O : \{O_1, \dots, O_6\}$, the plaintiff's theory T_P contain five clauses, whereas the the defendant's theory T_D contain two clauses. The support sets for the evidence from both side are as seen in table 3. We remind the reader that a support set is the subset of a theory that is utilized to account for a given observation.

| Observation | Plaintiff support set | Defendant support set |
|-------------|-----------------------|-----------------------|
| O_1 | $\{T_{P5}, T_{P2}\}$ | $\{T_{D2}\}$ |
| O_2 | $\{T_{P5}, T_{P3}\}$ | $\{T_{D2}\}$ |
| O_3 | $\{T_{P5}, T_{P4}\}$ | $\{T_{D2}\}$ |
| O_4 | $\{T_{P5}, T_{P1}\}$ | $\{T_{D1}\}$ |
| O_5 | $\{T_{P5}, T_{P1}\}$ | $\{T_{D1}\}$ |
| O_6 | $\{T_{P5}, T_{P1}\}$ | $\{T_{D1}\}$ |

Table 3. Support sets for the observations

We remind ourselves that as described in section 4.4 and 4.5, T_P and T_D are comprised as shown in equation 35 and 36.

$$T_P = \{T_{P1}, T_{P2}, T_{P3}, T_{P4}, T_{P5}\} \quad (35)$$

$$T_D = \{T_{D1}, T_{D2}\} \quad (36)$$

The summation of the utility of each of the components of the plaintiff's theory T_P over all observations are as we can see in equation 37 to 41.

$$\sum_{j=1}^6 U(T_{P1}, T_P, I_{Pj}, O_j) = 3 \quad (37)$$

$$\sum_{j=1}^6 U(T_{P2}, T_P, I_{Pj}, O_j) = 1 \quad (38)$$

$$\sum_{j=1}^6 U(T_{P3}, T_P, I_{Pj}, O_j) = 1 \quad (39)$$

$$\sum_{j=1}^6 U(T_{P4}, T_P, I_{Pj}, O_j) = 1 \quad (40)$$

$$\sum_{j=1}^6 U(T_{P5}, T_P, I_{Pj}, O_j) = 6 \quad (41)$$

The coherence of plaintiff's theory can then be derived as in equation 42.

$$C(T_P, I, O) = \frac{1}{6} \times \frac{1}{5} \times (3 + 1 + 1 + 1 + 6) = 0.4 \quad (42)$$

For the case of the defendant, the summation of the utility of each of the component in the defendant's theory over all observations are seen as follows.

$$\sum_{j=1}^6 U(T_{D1}, T_D, I_{Dj}, O_j) = 3 \quad (43)$$

$$\sum_{j=1}^6 U(T_{D2}, T_D, I_{Dj}, O_j) = 3 \quad (44)$$

The coherence of the defendant's theory can be derived as done in equation 45.

$$C(T_D, I, O) = \frac{1}{6} \times \frac{1}{2} \times (3 + 3) = 0.5 \quad (45)$$

Our coherence measure shows that in the event that the explanations from both sides are considered equally valid, the defendant had provided a more coherent theory to account for the evidence.

5 Discussion and future work

We proposed an approach to evaluate cases in a legal dispute as two rival theories. The theories are measured by how well they account the evidence. The proposed measure of coherence rewards simple theories that account for a large body of evidence, while punishing frivolous theories that regard much of the evidence as exceptions. We gave an example of an actual legal dispute from the literature, and showed how the case fits into our framework. In the example, the side that lost due to insufficient evidence also had the less coherent theory.

We note that a key difference between scientific theories and cases in legal disputes is that scientific theories are evaluated primarily on how well they account for the evidence, whereas cases in legal disputes are ultimately concerned with proving a case in order to attain a goal. However, as the case is based on evidence, the quality of the theory in accounting for the evidence is still crucial in proving the case. We argue that our notion of coherence gives rise to an important measure to the quality of the case, and allow rival cases to be compared in a quantitative manner.

Our framework provides only a preliminary and approximate model in evaluating cases with respect to the given evidence. We intentionally chose a simplification of the case in order to illustrate our goal of assessing the coherence of rival theories between the plaintiff and the defendant. In more complicated real-life examples, not all evidence are treated equally, some would be considered worthy of more merit than others, and some would be contradictory. The differing merits of evidence can be modelled by allocating weights to the evidence and also components of the theory similar to the proposal by Li et al. [6]. Contradictory evidence could be handled by argument-based version of extended logic programming with defeasible priorities such as the one proposed by Prakken and Sartor [8]. Incorporating these features into the evaluating coherence is essential for extending our proposal to more complex legal disputes.

Our evaluation of coherence reflects the importance of the choice of evidence in a legal dispute. As the evidence of a legal dispute is central to our calculation of coherence of the respective cases, different selection of evidence can change the theories, thus leading to different outcomes in accordance with our coherence

measure. Therefore, intelligent allocation of the *burden of proof* is necessary to collect the relevant evidence in proving the cases, while avoiding material that may not necessarily relate to the case.

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