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Representing dimensions within the reason model of precedent

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Abstract This paper gives an account of dimensions in the reason model found in Horty (Legal Theory 17(1): 1–33, 2011), Horty and Bench-Capon (in: Proceedings of the 15th international conference on artificial intelligence and law, pp 109–118, ACM Press, 2012) and Rigoni (Artif Intell Law 23(2):133–160, 2015. doi:10.1007/s10506-015-9166-x). The account is constructed with the purpose of rectifying problems with the approach to incorporating dimensions in Horty (2017), namely, the problems arising from the collapse of the distinction between the reason model and the result model on that approach. Examination of the newly constructed theory revealed that the importance of dimensions in the reason model lies in their ability to establish weighings between reasons/factors of the same polarity. This permits past cases to constrain future cases in ways they could not on the reason model with just factors. The paper then discusses how dimensions might be established from a case base and how dimensions that are incomplete in various aspects might be dealt with in the theory. It closes with comparisons to other work in the literature on AI and Law and suggestions for further improvement of the reason model.

Case Based Reasoning · Precedent · Common Law Reasoning · Dimensions · Factors

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1 Introduction

Horty (2017) offers an implementation of dimensions within his factor based reason model of precedent. The resultant theory has an undesirable consequence, namely, the model of precedential constraint collapses into the a fortiori constraint of the result model, which was the initial problem that motivated shifting from the result model to the to the reason model. Horty resolves this problem in a way that he admits "may appear to be artificial, or ad hoc, especially given the somewhat technical problem through which it was motivated" (2017). This article offers an alternative approach to dimensions within the reason model that avoids appearing artificial or ad hoc.

The article has three main sections. The first section explains Horty's approach in more detail. The second section provides the alternative approach to modeling dimensions, which is developed as a response to the problems identified in the first section. The third section considers the relationship between the approach developed here and other models and discusses general issues and ideas regarding dimensions and the reason model.

2 Problems with the previous approach to dimensions in the reason model

Horty (2011) persuasively argued that a result model of precedent was inadequate to capture features of legal reasoning with precedent. The result model treated cases as sets of pro-plaintiff and pro-defendant factors (or reasons, I use the terms interchangeably), with the holding of a case being a weighing on which the set of all the factors favoring the winning side outweigh the set of all the factors favoring the losing side. This holding was the binding rule of the case according to the result model. The reason model allowed for holdings that establish a weighing on which a subset of all the factors favoring the winning side outweigh the set of all the factors favoring the losing side. This offered the advantage of accommodating the distinction between *ratio* and *dicta* as well as accommodating cases where the court clearly sees the result as overdetermined. The reason model was further refined and expanded in Horty and Bench-Capon (2012) and Rigoni (2015). The focus of the reason model was to model precedential constraint, i.e., when precedent binds a legal decision-maker, see Rigoni (2014, sec. 2), and not to model every aspect of legal reasoning.

The reason model still used simple factors, like those used in CATO (Aleven 1997) and many other newer theories (Ashley and Brüninghaus 2009; Bex et al. 2011; Chorley and Bench-Capon 2003), rather than dimensions, like those used in HYPO (Ashley 1990). Recently there has been a movement to re-incorporate dimensions, see Al-Abdulkarim et al. (2015), Araszkiewicz (2011), Prakken et al. (2015) and the discussion in Bench-Capon (2017, sec. 7). Horty's recent work is an attempt to introduce dimensions into the reasons model. I will not take up the details of his account here, I refer the interested reader to his concise and dense paper

(2017). What matters for my purpose are two problems that the account has, both of which are explicit in that paper.

First, as Horty points out (2017, sec. 3), his account collapses the reason model into the result model. This is a problem because weaknesses of the result model motivated the adoption of the reason model (Horty 2011). Horty does offer some discussion about addressing this problem by limiting the kinds of rules that can impose constraint, but the solution, as Horty admits, requires further research and may seem ad hoc (2017). I will not evaluate Horty's solution. Instead, I integrate dimensions in a way that does not raise the problem of collapse into the result model.

An example from Horty's paper (2017, sec. 3.2) illustrates the kind of troubling results his model produces within the limitation on the kinds of rules cases can introduce. The imaginary example involves cases in which the plaintiff taxing authority is arguing the defendant taxpayer cannot claim a change of domicile to avoid paying tax. The case base contains one precedential case, in which the court determined whether the taxpayer had changed his fiscal domicile based on the period of time he spent abroad. Here the taxpayer (defendant) wants a finding that his domicile had changed. The relevant dimension in this case is the length of the stay abroad. The longer the stay, the stronger the reason in favor of finding a change of domicile. In the case in the case base the defendant spent 30 months abroad. The case was decided for the defendant on the basis of a rule which states that if the taxpayer defendant spent at least 12 months abroad, then he has changed his domicile. That is, the rule states, "if the time aboard $\geq$ 12 months, then rule for the defendant". There are no other reasons at issue in the case. Against this background, a court bound by this precedent considers a new case where the new taxpayer (defendant) has spent 18 months abroad, and there are no other reasons present. Can this court rule for the tax authority?

The natural response is "no". After all, the previous court just established a rule that if the length of the stay was at least 12 months, then you should rule for the defendant. Here the taxpayer (defendant) has spent more than a year abroad. This intuition accords with the approach of the non-dimensional reason models of Horty (2011) and Horty and Bench-Capon (2012). In those reason models, rules create a ordering of reasons such that the set of reasons in the premise of the rule outweigh any reasons for the losing party that are present in the case. This allows for rules that must be followed in certain cases, but can be defeated in others, when there is a reason favoring the other side which was not present in the past case. As mentioned before, the focus on the set of reasons in the premise of the rule allowed those theories to go beyond a fortiori reasoning of the result model (Horty 2011). On that view, the rule in the previous case should create a weighing such that the pro-defendant reason of having spent at least 12 months aboard outweighs the empty set of pro-plaintiff reasons.[1] The intuitive way of deciding the current case is to say that since the defendant has spent 18 months aboard, the pro-defendant reason of having

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[1] That the set of pro-plaintiff reasons is empty is part of Horty's example, but inessential. What matters is just that the set of pro-plaintiff reasons, outside of those related to the time abroad, remain unchanged in the past and current case.
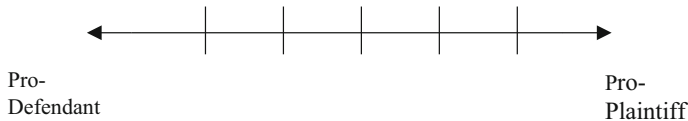
Fig. 1 A dimension, *D1*

spent 12 months aboard is present, and, according to the established weighing from the previous, this is sufficient to outweigh the empty set of pro-plaintiff reasons.

Horty (2017, sec. 3.2) provides a different answer. In his Example 1 he states that the current court is able to issue a ruling against the defendant in the current case. He explains that court could consistently impose a rule to this effect: if the time abroad is less than 24 months, then rule for the plaintiff. This result flies in the face of the intuitions that motivate the reason model. If the rule is that only 12 months abroad is needed to decide for the taxpayer, then a second court should not be able to decide against a taxpayer who spent 18 months abroad, without the presence of novel reasons in the second case. The next section constructs an alternative that avoids it.

3 An alternative approach

The alternative I develop ultimately reduces dimensions into the familiar reasons of the reason model, as opposed to Horty (2017), which reduces reasons into the newly created dimensional factors. The underlying thought is that dimensions are ordered sets of reasons. This idea is hardly new, see, for example, Bench-Capon (2002) and Bex et al. (2011, n. 2), but it has yet to be integrated into the reason model. Think of a dimension as a line with a pro-defendant and pro-plaintiff end. Consider the dimension *D1* found in Fig. 1 as an example:

Each point on the line is a reason for one side of the dispute. For the dimension of time spent abroad from the previous examples, this line would end with zero on the far right (pro-plaintiff side) and presumably extend infinitely to the left with length of time increasing in that direction. To maintain any kind of factor-based approach at all, whether it be a reason or result model, we have to assume that at some point on the dimension the polarity shifts. Hence, for some point on our dimension, all the points to its right/left will favor the plaintiff/defendant. Call this the "switching point", or *SP* (Fig. 2). [2]

The further one gets in either direction from *SP*, the stronger the reasons get for that party. In Fig. 3, R_1^d is a weaker reason for the defendant than R_2^d.

For example, in the domicile example from Sect. 2, R_1^d would be having a 12 month stay abroad where as R_2^d would be having an 18 month stay abroad. As another example, consider a dimension, D_3, roughly taken from trade secrets cases, with three points: R_1^p: weak protective measures taken, R_2^p: moderate protective measures taken, and R_3^p: strong protective measures taken. As the notation indicates,

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[2] The switching point receives a formal definition below.
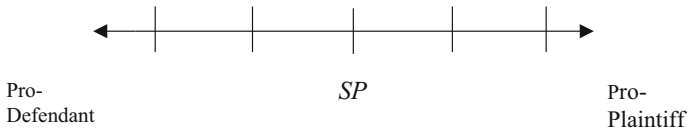
Fig. 2 *D1* with a switching point, *SP*

Fig. 3 The pro-defendant segment of dimension *D1*
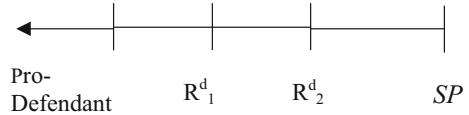
each of these favors the plaintiff and they are ordered on the dimension in this way: $R_1^p <_{D3} R_2^p <_{D3} R_3^p$. The presence of strong protective measures is a stronger reason for the defendant than presence of moderate protective measures, which is stronger than the presence of weak protective measures.[3]

As I will show later, I want to allow dimensions where no specific switching point has been fixed. To permit this, I must distinguish points on a dimension from factors on a dimension. Points on a dimension are the various points on the dimension. They can be ordered, where greater points on the ordering are stronger for the plaintiff or weaker for the defendant and lesser points are weaker for the plaintiff or stronger for the defendant. A factor is a point with a defined pro-plaintiff or pro-defendant valence. For example, on the dimension for the length of stay abroad, without knowing whether 50 months abroad is a pro-plaintiff or pro-defendant factor, a judge still knows that a 50 month stay is more pro-defendant than 40 months abroad. This means it's either a stronger pro-defendant factor, a weaker pro-defendant factor, or within the switching point. With the distinction between points and factors, I can formally define dimensions, dimensional factors, and the switching point as follows:

> *Dimension* A dimension, D_n, is a (partially) ordered set of points, $v_1 \ldots v_n$, such that if $v_1 >_{D1} v_2$, then v_1 is more pro-plaintiff than v_2 and v_2 is more pro-defendant than v_1.[4]

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[3] This is based on a similar dimension with more points from HYPO (Ashley 1991). In general, my approach lies between the dimensions of HYPO and the factors of CATO. HYPO allowed dimensions that were continuous (like the length of time abroad), enumerated (like the security measures), Boolean (only extrema are considered), and unary (only point is considered. I convert these to factors. The conversion for Boolean and unary dimensions is straightforward. For enumerated dimensions, I identify factors as corresponding to points or ranges of points on the dimension. For continuous dimensions my strategy is the same, though a great many factors may be required. The approach is very similar to that found in Bench-Capon and Bex (2015) and Prakken et al. 2015), insofar as the dimensions are all treated as order sequences ranges which can then be converted into factors. I am thankful to a reviewer for stressing this comparison.

[4] I use the letter "v" for points instead of the letter "p" to avoid confusion with the notation for pro-plaintiff factors. I had initially called points on a dimension "values," hence the "v", but switched to "points" in order to avoid confusion with the different kind of values discussed in Sect. 4.

Dimensional factor A point on a dimension with a polarity of either pro-plaintiff or pro-defendant. Dimensional factors retain the ordering of their corresponding points, so for all pro-defendant dimensional factors, R_1^d, there exists no pro-plaintiff dimensional factor, R_1^p, such that $R_1^p \leq_{Dn} R_1^d$.

Switching point A point (or range of points treated as a single point) on dimension, D_1 such that for all points, v_1, such that $v_1 >_{D1} SP$, v_1 corresponds to a pro-plaintiff factor, and for all points, v_2, such that $v_2 <_{D1} SP$, v_2 corresponds to a pro-defendant factor

Note that $<_{Dn}$ and $>_{Dn}$ are not the same as the $<$ and $>$ used to weigh reasons in the reason model. $<$ and $>$ only hold between reasons of differing polarities in the reason model, while $<_{Dn}$ and $>_{Dn}$ hold between reasons of any polarity. For some dimensions the switching point will be a single range of neutral points, i.e., points that do not correspond to a dimensional factor for either party. Suppose we have a tort case involving a traffic accident at an intersection with a traffic light. Suppose that the traffic light being green with a left turn arrow at the time of the accident strongly favors the defendant, the light being green without the arrow less strongly favors the defendant, the light being red at that time favors the plaintiff, and the light being yellow at that time does not help us determine fault. Here the light being yellow would be a neutral point and also the switching point. For other dimensions, there will be multiple switching points. Consider again the traffic light, but suppose that the light being yellow favors the plaintiff less strongly than a red light. Then both the light being yellow and the light being green without an arrow are switching points according to the definition.[5] Often the precise location of the switching point will not be established, so it will not be clear which of these types a particular dimension is. This is discussed further in Sect. 3.

The next step is to introduce dimensions into the case base. This could be done directly, by adding them independent of the cases as a kind of background information for the rest of the case base. I opt for a different approach on which cases can introduce dimensions. This means adding a component to the representation of cases. The standard representation of cases in the reason model is fourfold: (1) reasons in favor of the plaintiff. I denote standard reasons with "R_n^p" where n is a number used to differentiate multiple reasons for the plaintiff. For dimensional factors, I will use "R_{Vn}^p" where Vn is the point on the dimension corresponding to the reason; (2) reasons in favor of the defendant. I denote standard reasons with "R_n^d" where n is a number used to differentiate multiple reasons for the defendant. For dimensional factors, I use "R_{Vn}^d" where Vn is the point on the dimension corresponding to the reason; (3) an outcome, which I will denote with a "P ☺" when it is a ruling in favor of the plaintiff and with a "D ☺" when it favors the defendant; (4) a rule, which I will denote "Rule$_n$" where n is a number used to differentiate different rules from different cases. To these four components, I now add a fifth, (5), which is a set (potentially empty) of dimensions, as they are defined above.[6]

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[5] Matters can be more complicated if the range of points is dense.

[6] This will be a set of ordered sets. Throughout the article I assume that cases only involve one dimension.

In cases that do not involve dimensions, (5) will be $\emptyset$. In cases that do involve dimensions, (5) will contain each corresponding dimension. Once a particular dimension is introduced by one case it can be re-used in later cases.[7] The example of the length of a stay abroad works like this. That same dimension appears in many cases where courts must determine fiscal domicile.

Consider a fiscal domicile case where the taxpayer defendant has spent 12 months aboard. Let's add a single pro-plaintiff (tax authority) reason: that the taxpayer conducted business with his home country while abroad. Applying our new fivefold representation scheme yields this: (1) The reasons in favor of the plaintiff, R_1^p, where R_1^p is that the defendant conducted business with his home country while abroad; (2) The reasons, which here are dimensional factors, in favor of the defendant, $\{R_{V1}^d\}$, where V_1 is point of 12 months, and R_{V1}^d is the corresponding reason for a stay of at least 12 months; (3) The outcome, D ☺; (4) The rule, $R_{V1}^d \rightarrow$ D ☺; (5) The set of dimensions, $\{D_1\}$, where D_1 is the dimension of length of stay abroad. The weighing of reasons introduced by this case is $R_{V1}^d > R_1^p$.

Now that we have an example of how cases are represented, I introduce two sample cases, simplified versions of the first two cases discussed in Sect. 2.

Case 1 D spent 30 months abroad. The court rules that his domicile has changed because he spent at least 12 months abroad. Let the following be its formalization: $\{\emptyset, \{R_{V1}^d, ??\}, D☺, R_{V1}^d \rightarrow D☺, D_1\}$. This introduces the trivial weighing $R_{V1}^d, ?? > \emptyset$.

Case 2 D spent 18 months abroad. The court rules that his domicile has not changed because he did not spend more than 24 months aboard. Let the following be its formalization: $\{ R_{V2}^p, \emptyset, P☺, R_{V2}^p \rightarrow P☺, D_1\}$. This introduces the trivial weighing $R_{V2}^p > \emptyset$.

As we saw in the discussion of Horty's example case in Sect. 1, Case 1 and Case 2 are inconsistent. The question marks indicate that I have not yet established how to characterize the factors beyond the factor of a 12 month stay. However, the inconsistency between the cases can be established without it. From the point of view of precedential constraint within the reason model, the reasons favoring the winning side that are not part of the ratio are superfluous. A revised Case 1 with a stay of only 12 months produces the same binding weighing of reasons as Case 1.[8]

The inconsistency stems from D_1, V_1, and V_2. V_1 is the point of 12 months abroad and V_2 is the point of 24 months abroad. We know that D_1 orders larger points (longer stays) below smaller points (shorter stays). Hence $V_1 >_{D1} V_2$, which means V_2 must be more pro-defendant than V_1, and from our definition of dimensional factors, it follows that they must respect the ordering of the points. Yet, Case 2 has V_2 generating a pro-plaintiff factor while Case 1 has V_1 generating a pro-defendant

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[7] For discussion on how a dimension can be introduced, see Al-Abdulkarim et al. (2013) and Ashley (1991).

[8] If cases were characterized using all the factors favoring the losing side and only the remaining factors that were part of the ratio, then the reason and result model are equivalent. This comes at the cost of representing cases that seem very different as equivalent, as the example with the revised Case 1 showed.

factor. Clearly, Case 2 runs afoul of our rules for dimensions because it does not treat V_2 as more pro-defendant than V_1. Another way of thinking of this is using the idea of the switching point. If Case 1 is acceptable according to D_1, then the switching point must be at some point above V_1 in the ordering (i.e., at a time of less than 12 months), because Case 1 puts a pro-defendant factor at V_1. But Case 2 requires a switching point at some point below V_2, because Case 2 puts a pro-plaintiff factor at V_2. This is impossible since $V_1 >_{D1} V_2$. The inconsistency is even more obvious if D_1 has an established switching point independent of Case 1, as discussed in Sect. 3, but that need not be assumed to show the inconsistency.

The question of how to characterize the 30 month stay in Case 1 is difficult, and my preferred solution will be clearer after considering some other cases to further flesh out the theory. Consider the example cases below using the dimension, D_3, taken from the domain of trade secrets. As mentioned above, D_3 includes the following three members: R^p_{V1}: weak measures taken, R^p_{V2}: moderate protective measures taken, and R^p_{V3}: strong protective measures taken.[9] We may add a fourth, pro-defendant value: R^d_{V1}, which corresponds to no protective measures being taken. As the notation indicates, each of the factor favors the plaintiff and they are ordered on the dimension in this way: $R^p_{V1} <_{D3} R^p_{V2} <_{D3} R^p_{V3}$.

Case 3 Plaintiff saved the supposedly secret data on a device with software encryption. The court derived R^p_{V2} from this fact. That is, the court found that saving on a device with software encryption established that moderate protective measures were taken. The court also finds that R^d_1, a non-dimensional pro-defendant reason, is present. The court rules that the presence of moderate protective measures is sufficient to decide the case. Let the following be its formalization: $\{ R^p_{V2}, R^d_1, P\copyright, R^p_{V2} \to P\copyright, D_3 \}$. The weighing introduced by this case is $R^p_{V2} > R^d_1$.

Case 4 Plaintiff saved the supposedly secret data on a device with hardware encryption. The court derived R^p_{V3} from this fact. That is, it found that saving the data on a device with hardware encryption established that strong protective measures were taken. The court also finds R^d_1, the same non-dimensional pro-defendant reason found in Case 3, is present. The court rules that the presence of R^d_1 is sufficient to decide the case. Let the following be its formalization: $\{R^p_{V3}, R^d_1, D\copyright, R^d_1 \to D\copyright, D_3\}$. The weighing introduced by this case is $R^d_1 > R^p_{V3}$.

Cases 3 and 4 seem intuitively inconsistent, because Case 4 treats R^p_{V3} as weaker than R^p_{V2}, though according to D_3 R^p_{V3} should be stronger than R^p_{V2}. More specifically, we expect R^p_{V3} to defeat any pro-defendant that is defeated by R^p_{V2}. The model needs to be refined to ensure this, which brings us back to issue the of the relationship between the ordering on the dimension and the weight of reasons—of $<_{Dn}$ and $>_{Dn}$ versus $<$ and $>$. There may be a good justification for not allowing,

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[9] The points here are "weak protective measures," "moderate protective measures," and "strong protective measures" for V_1, V_2, and V_3, respectively.

in general, the weighing of reasons of the same polarity.[10] However, the whole point of dimensions is that they order reasons on them in terms of the strength provided to either party. If you want to use dimensions, you must approve of weighing reasons of the same polarity.

The theory needs to allow the ordering of dimensions to affect the weighing of reasons. The following rules capture the appropriate interaction between the two:

3.1 Weighing rule for pro-plaintiff dimensional factors (WRPP)

I. For any pro-plaintiff reason, R_{Vn}^p, on a dimension, D_n, if there is a pro-defendant reason (or set of pro-defendant reasons), R_{Vm}^d, such that $R_{Vn}^p > R_{Vm}^d$, then for all pro-plaintiff reasons, R_{Vx}^p, on D_n such that $R_{Vx}^p >_{Dn} R_{Vn}^p$, $R_{Vx}^p > R_{Vm}^d$. Formally, $\forall \ R_{Vn}^p((\exists D_n(ison(R_{Vn}^p, D_n))) \to (\exists R_{Vm}^d(R_{Vn}^p > R_{Vm}^d) \to \forall \ R_{Vx}^p((R_{Vx}^p >_{Dn} R_{Vn}^p) \to (R_{Vx}^p > R_{Vn}^d)).$

II. For any pro-plaintiff reason, R_{Vn}^p, on a dimension, D_n, if there is a pro-defendant reason (or set of pro-defendant reasons), R_{Vm}^d, such that $R_{Vm}^d > R_{Vn}^p$, then for all pro-plaintiff reasons, R_{Vx}^p, on D_n such that $R_{Vx}^p <_{Dn} R_{Vn}^p$, $R_{Vx}^p < R_{Vm}^d$. Formally, $\forall R_{Vn}^p((\exists D_n(ison(R_{Vn}^p, D_n))) \to (\exists R_{Vm}^d(R_{Vn}^p < R_{Vm}^d) \to \forall R_{Vx}^p((R_{Vx}^p <_{Dn} R_{Vn}^p) \to (R_{Vx}^p < R_{Vm}^d).).$

3.2 Weighing rule for pro-defendant dimensional factors (WRPD)

I. For any pro-defendant reason, R_{Vn}^d, on a dimension, D_n, if there is a pro-plaintiff reason (or set of pro-plaintiff reasons), R_{Vm}^p, such that $R_{Vn}^d > R_{Vm}^p$, then for all pro-defendant reasons, R_{Vx}^d, on D_n such that $R_{Vx}^d <_{Dn} R_{Vn}^d$, $R_{Vx}^d > R_{Vm}^p$. Formally, $\forall R_{Vn}^d((\exists D_n(ison(R_{Vn}^d, D_n))) \to (\exists R_{Vm}^p(R_{Vn}^d > R_{Vm}^p) \to \forall R_{Vx}^d((R_{Vx}^d <_{Dn} R_{Vn}^d) \to (R_{Vx}^d > R_{Vm}^p).).$

II. For any pro-defendant reason, R_{Vn}^d, on a dimension, D_n, if there is a pro-plaintiff reason (or set of pro-plaintiff reasons), R_{Vm}^p, such that $R_{Vn}^d < R_{Vm}^p$, then for all pro-defendant reasons, R_{Vx}^d, on D_n such that $R_{Vx}^d >_{Dn} R_{Vn}^d$, $R_{Vx}^d < R_{Vm}^p$. Formally, $\forall R_{Vn}^d((\exists D_n(ison(R_{Vn}^d, D_n))) \to (\exists R_{Vm}^p(R_{Vn}^d < R_{Vm}^p) \to \forall R_{Vx}^d((R_{Vx}^d >_{Dn} R_{Vn}^d) \to (R_{Vx}^d < R_{Vm}^p).).$

The effect of these rules is that any weighing of a pro-plaintiff reason, R_{Vn}^p, on D_n over a (set of) pro-defendant reason(s) entails the weighings of each pro-plaintiff reasons $>_{Dn} R_{Vn}^p$ over that (set of) pro-defendant reason(s). Further, any weighing of a (set of) pro-defendant reason(s), over a pro-plaintiff reason, R_{Vn}^p, on D_n entails the weighings of that (set of) pro-defendant reason(s) over each pro-plaintiff reason

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[10] Horty (2012) offers a brief discussion of some of possible justifications.

$<_{Dn}R^p_{Vn}$. Likewise, any weighing of a pro-defendant reason,R^d_{Vm}, on D_n over a (set of) pro-plaintiff reason entails the weighings of all pro-defendant reasons $<_{Dn}R^d_{Vm}$ over that (set of) pro-plaintiff reason(s). Further, any weighing of a (set of) pro-plaintiff reason(s),over a pro-defendant reason,R^d_{Vm}, on D_n entails the weighings of that (set of) pro-plaintiff reason(s) over each pro-defendant reason $>_{Dn}R^d_{Vm}$. Therefore, when a holding is reached that weighs a dimensional reason, it produces not only a weighing for the reasons actually weighed, but additional weighings for reasons stronger/weaker on the dimension.

Turning back to the examples, the WRPP will make Case 4 inconsistent with case Case 3. From Case 3 we know $R^p_{V2} > R^d_1$. By WRPP it follows that any pro-plaintiff reason $>_{D3}R^p_{V2}$ must outweigh R^d_1. $R^p_{V3} >_{D3}R^p_{V2}$, so $R^p_{V3} > R^d_1$. Case 4 has $R^d_1 > R^p_{V3}$, which is inconsistent on the Reason model (and the result model as well). WRPD guarantees similar results when the polarity of the reasons is switched.

I can now discuss the representation of the 30 month stay from Case 1. There are a few options for representing that case to show that it was stronger for the defendant (taxpayer) than a case with a 12 month stay. One option, following the shift in the treatment of dimensions from HYPO to CATO,[11] is to treat that case as involving a factor for a 30 month stay as well as all the weaker factors entailed by a 30 month stay. That is, the representation would involve a factor for the 30 month stay, a factor for a 20 month stay, a factor for a 12 month stay, and so on. This is undesirable for a number of reasons. First, it would greatly expand the number of dimensional factors present in each case. Second, it requires that we fix the ranges of points corresponding to the weaker factors, i.e., it requires us to determine whether a 20 month stay is a different factor than a stay of 20 months and 1 day. If we don't fix those ranges, then we won't know which factors are included in this case. Third, it requires that we fix a switching point, because the weakest factor for a side is going to be entailed by any factor for that side.

Finally, the notion of entailment between factors seems artificial. For the taxpayer cases it seems intuitive that the factor for a 30 month stay entails the factor for a 12 month stay because the *fact* of a 30 month stay, which underlies the factor, entails the *fact* of a 12 month stay, which underlies that factor.[12] Yet in other cases the entailment will be far from obvious. Suppose you have a dimension of security measures taken to protect data with four points: no measures, weak measures, moderate measures, strong measures. The first point, no measures, corresponds to a pro-defendant factor while the other three correspond to pro-plaintiff factors of ascending strength. Why should we think that taking moderate measures entails taking weak measures? It's easy to think of incompatible facts underlying each

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[11] CATO represents a point on a dimension as strict superset of the factor(s) corresponding to the weaker points. As Prakken et al. put it, "That is to say, as we move along the HYPO dimension we collect more and more CATO factors. The increased degree of support is thus given by the cumulative effect of several factors, rather than distinguishing the difference of degree of support given by different positions on the dimension" (2015).

[12] However, the *fact* of a 30 month stay also entails the *fact* of a 2 days stay, but a 2 days stay likely corresponds to a pro-plaintiff factor. You do not want the pro-taxpayer factor of a 30 month stay to entail the pro-tax authority factor of a 2 days stay. You can adjust for this by characterizing the pro-plaintiff factors as "at most a—month stay" while the pro-defendant factors are "at least a—month stay".

factor. Suppose the weak protection factor is established if and only if the data is stored unencrypted in a private place, while the moderate protection factor is established if and only if the data is stored on an encrypted drive in a public place, and the strong protection factor is established if and only if the data is encrypted and stored in a private place. If the current case involves encrypted data stored in a public place, the court should find that moderate measures factor is present. However, the approach considered here also requires this case to be represented as involving weak measures, even though we know that facts required for finding weak measures are inconsistent with the facts in the case. There are better alternatives available. I discuss two below.

The first is to characterize each case involving dimensional factors as containing only standard reasons (if any), the strongest dimensional factor[13] present in the case, and the dimensional factor (if any) that is used in the ratio of the case. This would make the set of pro-plaintiff factors in Case 1 $\{R_{V1}^d, R_{V9}^d\}$. Here the first factor, R_{V1}^d, corresponds to a to a 12 month stay, and appears in the representation because it occurs in the ratio. The second factor, R_{V9}^d, corresponds to a 30 month stay. It appears because it is the strongest dimensional factor present in the case. The full characterization of the case is then $\{\{R_{V1}^d, R_{V9}^d\}, D\text{☺}, R_{V1}^d \rightarrow D\text{☺}, D_1\}$.

The second option follows a suggestion from (Rigoni 2015, sec. 4.2.2) and allows cases to have ratios that involve factors that are not present in the case, though ratios must take as their antecedent either a subset of the standard factors favoring the winning side or the union of a subset (possibly empty) of the standard factors favoring the winning side and set of a dimensional factors, each of which is weaker than the dimensional factors present within the case. This approach characterizes each case involving dimensional factors as containing only standard reasons (if any), and the strongest dimensional factor present in the case. Hence the set of factors in Case 1 is just $\{ R_{V9}^d \}$, but the ratio for that case need not involve R_{V9}^d. Instead the ratio is involves only R_{V1}^d, which is permissible because that is a union of an empty subset of standard factors and a dimensional factor, R_{V1}^d, which is weaker than the dimensional factor present in the case, R_{V9}^d. The full characterization is $\{\varnothing, \{ R_{V9}^d \}, D\text{☺}, R_{V1}^d \rightarrow D\text{☺}, D_1\}$.

I use the second approach because it makes the representations of case a bit briefer, but either approach works well enough for my purposes. One might worry that, on the second approach, the rule from Case 1 cannot guarantee the same result even in an identical future case, since the rule is not triggered in absence of R_{V1}^d and an identical case will only R_{V9}^d as the factor that is present. However, what is important for constraining future decisions is the weighing the rules generate. The rule from Case 1 establishes that R_{V1}^d outweighs the set of pro-plaintiff (tax authority) reasons, which happens to be $\varnothing$. WRPD requires that no dimensional factor that is stronger than R_{V1}^d can be outweighed by that same set of pro-plaintiff reasons (here, $\varnothing$). According to D_1, R_{V9}^d is stronger than R_{V1}^d, hence it must outweigh $\varnothing$. Therefore, a ruling for the plaintiff (tax authority) in an identical future

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[13] This would be done for each dimension, but I've stipulated for simplicity that only one dimension is present in the cases. The extension to additional dimensions is clear.

case is impermissible, because that ruling would make $\varnothing$ outweigh R_{V9}^d. Thus in an identical case, the court must rule for the taxpayer (defendant).

I close this section with a final pair of examples demonstrating how the model with the second approach works.

Case 5 Plaintiff first saved the supposedly secret data on a device with hardware encryption. The court derived R_{V3}^p from these facts. The court also finds that R_1^d, a non-dimensional pro-defendant reason, is present. The court rules that the presence of moderate protective measures is sufficient to decide the case. Let the following be its formalization: { R_{V3}^p, R_1^d, P☺, $R_{V2}^p \rightarrow$ P☺, D_3}. The weighing introduced by this case is $R_{V2}^p > R_1^d$, and also $R_{V3}^p > R_1^d$ in accordance with WRPP.

Case 6 Plaintiff saved the supposedly secret data on a device with software encryption. The court derived R_{V2}^p from this fact. The court also finds R_1^d, the same non-dimensional pro-defendant reason found in Case 5, is present. The court rules that the presence of R_1^d is sufficient to decide the case. Let the following be its formalization: { R_{V2}^p, R_1^d, D☺, $R_1^d \rightarrow$ D☺, D_3}. The weighing introduced by this case is $R_1^d > R_{V2}^p$, and also $R_1^d > R_{V1}^p$ in accordance with WRPD.

Cases 5 and 6 are clearly inconsistent because they produce the inconsistent pair of weighings $R_{V2}^p > R_1^d$ and $R_1^d > R_{V2}^p$. Note that the two cases are consistent on a result model of precedent, because Case 6 is a weaker case for the plaintiff than Case 5. Thus we can see that my model retains the advantages of the reason model that are lost on the approach in Horty (2017).

4 Discussion: the two roles of dimensions

The theory constructed here retains what is desirable about the reason model while accommodating factors that fall along a dimension in a straight-forward way. It's worthwhile to discuss the role of dimensions in literature on AI and legal reasoning, and how this theory addresses these roles. Bench-Capon (2017, sec. 7) offers a nice review of the history of this issue. As I see it, dimensions play two roles: (1) they allow cases to impose precedential constraint beyond that offered by regular factors, and (2) they allow representation of and argument at a lower level of abstraction (more factual) than factors. I discuss each in turn.

4.1 The constraining force of dimensions

As the focus of the reason model is precedential constraint, the primary importance of dimensions to that model is in their ability to bind future decision makers. Dimensions go beyond regular factors insofar as they allow for comparisons of strength between reasons of the same polarity and they produce orderings that are not explicit in the case base. That is, they produce binding weighings of reasons even when the reasons have not been compared in any case. This is clear in Case 6,

which produces the weighing $R_1^d > R_{V1}^p$, despite not involving $> R_{V1}^p$. Even though no court has considered R_{V1}^p versus R_1^d, their relative weights have been established. This cannot happen using traditional factors. One way to see this difference is to consider the follow case as occurring in a context where the only past case is Case 6.

> *Case 7* Plaintiff saved the supposedly secret data on a device without software encryption, but a device that only the plaintiff used. The court derived R_{V1}^p from this fact. The court also finds R_1^d, the same non-dimensional pro-defendant reason found in Case 5, is present. The court rules for the plaintiff. Let the following be its formalization: { R_{V1}^p, R_1^d, D☺, $R_{V1}^p \rightarrow$ D☺, D_3}. The weighing introduced by this case is $R_{V1}^p > R_1^d$, and also $R_{V2}^p > R_1^d, R_{V3}^p > R_1^d$.

Case 7 is obviously inconsistent with case Case 6. However, using only traditional factors, Case 7 is consistent with Case 6, because Case 6 would not impose any weighing on R_{V1}^p. Put another way, on the standard factor view Case 7 would involve a novel reason, R_{V1}^p, and hence could be distinguished from Case 6. On the dimensional approach adopted here the judge in Case 7 is not permitted to distinguish the present case from Case 6.

In all of my examples, I have assumed that a complete dimension is already established. A complete dimension is defined as follows:

Complete dimension A dimension with these three features:

1. The location of the switching point as well as to what kind of factor, if any, it corresponds is fixed.
2. There is a total ordering of the points.
3. All the points on the dimension are established.

An incomplete dimension is a dimension that is not complete. Knowing a complete dimension and knowing that it is complete provides a great deal of data to the decision maker. Per (1) she knows which point is the switching point, as well as whether that point corresponds to a pro-plaintiff factor, a pro-defendant factor, or no factor at all. Per (3), she knows what each of the points is. For example, suppose D_1 is complete, has its points differentiated by month, and is known to the judge. Then she know that one point is 12 months, another is 13 months, another is 14 months, another is 15 months. She is able distinguish D_1 from a similar dimension where the points are differentiated by day.

Now consider D_3. If D_3 is complete and known to the judge, then she knows that on the pro-plaintiff side one point is "weak protective measures taken," another point is "moderate protective measures taken," and the last point is "strong protective measures taken". She knows the switching points are at "weak protective measures" and "no protective measures." She can then distinguish D_3 from another dimension of the degree of proactive measures that has more than four points. Knowing (1) and (2) and (3), she knows, for every point on the dimension, whether it corresponds to a factor, and the polarity and strength of that corresponding factor, if there is one.

A complete dimension provides all the aforementioned information, and can be provided as a background to use when characterizing and deciding cases. However, dimensions have to come from somewhere, and the natural place to look is in past cases. Just what it means for a past case or cases to establish a dimension is a difficult but necessary question. Currently, that question will have to await future work, though (Al-Abdulkarim et al. 2013) provides a good starting point. I will explore how the theory can work with dimensions that are established, but incomplete.

There are three ways a dimension can be incomplete, namely, by lacking a fixed switching point (1), a total ordering (2), or all the points (3). Of course, a single dimension can be incomplete in more than one of these ways. Yet, it is helpful to consider each in isolation. As I see it, dimensions can be more or less completely established. Consider first dimensions that have a total ordering and all the points established, but lack a fixed switching point. For example, D_1 has not been assigned a switching point. Suppose a judge knows the points (just the span of months from 0 to ∞) and the ordering (lower numbers of months are more pro-defendant, higher numbers of months are pro-plaintiff). From Cases 1 she knows that the switching point must be at or above (according to the weighing, so at 12 months or some less number of months) 12 months, since that point is treated as corresponding to a pro-defendant factor. However, she does not know whether the point of 10 months corresponds to a pro-plaintiff or pro-defendant factor, or neither, if it is a neutral point. Further cases can further narrow the range of possible locations for the switching point, and this can provide a great deal of information and constraint without fixing a precise switching point. Still, until the switching point is fixed, cases where the polarity of the point's corresponding factor is not determined by precedent. The switching point could be fixed, for example, if a high level court held that the length of a particular taxpayer's stay abroad was the bare minimum needed to establish a foreign domicile.

Dimensions that lack (2) but have (1) and (3) would be ones where the ordering is only partially established but all the points and switching point are known. Here is a stylized example: suppose we have a tort case involving an automobile crash. One dimension relevant to the case is the speed of the defendant's vehicle. Suppose that there is a speed limit of 70 mph and a speed minimum of 50 mph in the area of the crash.[14] Let there be one pro-defendant factor, which corresponds to the whole range of speeds between 70 and 50 mph. This factor is a fixed switching point.[15] We know all the points on the dimension, since it's just a numeric range of speeds. At speeds above 70 mph, the higher the speed, the stronger the corresponding pro-plaintiff factor is. Likewise, at speeds lower than 50 mph, the lower the speed, the stronger the corresponding pro-plaintiff factor is. Thus, there is a partial ordering, because we know the strength of speeds of over 70 mph (under 50 mph) relative to other speeds over 70 mph (under 50 mph), but we do not know the strength of speeds over 70 mph relative to speeds under 50 mph. and the strength of speeds less than 50 mph relative to other speeds less than 50 mph.

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[14] Interstates in Florida have such limits, see Fla. Stat. 316.183 (2017).

[15] Technically the weakest pro-plaintiff factor will also be a switching point.

This dimension will constrain a current judge just as much as a complete dimension if the case base and current case involve points within the known ordering. e.g., let the speed in the current case be 80 mph and let there be one pro-defendant factor present as well. If the case base shows tells us that speed of 75 mph is stronger than that same pro-defendant factor, the current court cannot hold for the defendant.

It's clear how the theory allows for establishing parts of an order in a piecemeal fashion. After the judge makes a decision in a case involving an unordered point, that point can begin to be ordered[16] For example, the judge previously mentioned may decide that the factor for a traveling 75 mph is outweighed by an opposing factor that was itself outweighed by the factor for traveling 40 mph statement in another case. The judge has then established that the 75 mph factor is weaker than the 40 mph factor. Unfortunately for my theory, orderings need not be established in this piecemeal manner. An opinion might say, "here the taxpayer stayed for 30 months, and longer stays offer stronger evidence for the defendant," and thereby fix the entire order for a dimension like D_1. There is no clean way of representing this in the current theory, because there only orderings between pairs of factors. If we knew all the factors corresponding to longer stays, we would need a weighing for each pair of factors such that the factor corresponding to the longer stay outweighed the other factor. Also, it is not clear whether a statement like this should be understood as precedential, which brings us back to the difficulties in characterizing a case from an opinion. This is another problem that awaits further work.

Dimensions that lack (3) but have (1) and (2) are ones where the switching point is fixed and all the known or established points have a ordering, but there are potentially new points that are unknown. As an example, consider one of the dimensions from the much discussed wild animal cases: the status of the land on which the animal was pursued. This is treated as two factors—one for land open to the public and the other for land owned by the hunter in Berman and Hafner (1993). It is treated as a dimension with multiple points in Bench-Capon and Rissland (2001) and later in Rissland and Ashley (2002, p. 70). Rissland and Ashley introduce it as dimension with two familiar points: open (i.e., land open to the public) and "own" (private land owned by the hunter). However, they note,

> a whole panoply of possible values could be elaborated, including lands or waters "open" to anyone, land owned by some governmental entity for the public's benefit (e.g., the town commons), land leased from some government or private entity for a particular purpose (e.g., pasture or shellfish beds), private land not owned by the hunter, or private land owned by the hunter but not posted with "no hunting" signs. Whether any of these values would be part of the dimension's expanded range, and in what order, depends on what other wild animal cases may say (Rissland and Ashley 2002, p. 72).

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[16] You can have cases where the weighing established by the case does not establish any ordering for the unordered point. For example, a case where we are told that an unordered point corresponds to a factor that is outweighed by a novel reason. Still, this provides the basis for a future ordering as other cases involving that previously novel reason are decided.

Here the dimension only has two known points, but all the circumstances mentioned by Rissland and Ashley are potential points as well. In a current case with one of these "new" points, the judge is largely unconstrained. She may decide not to treat the circumstance as a new point; for example, she might find that land leased from the government is equivalent to private land owned by the hunter and thereby treat the case as an instance of one of the known points. If she treats the current case as involving a new point, the point can be put any place within the ordering that does not make it equivalent to another point, i.e., any "open" place. She is free to put it on either side of the switching point and in any open place on the ordering. This freedom may be limited in practice if the ordering has few open places.

A single dimension can be incomplete in multiple respects. As an example, Rissland and Ashley (2002, p. 71) list 12 points for the dimension of degree of control over a wild animal, with only the two extrema having a fixed position in the ordering. Further, they mention that additional points are possible. This dimension is incomplete in all three aspects. This dimension barely constrains a judge any more than simple factors for the extrema do. The constraint only extends beyond simple factors in a case where one of the previously mentioned non-extrema points is present. Although the judge is free to treat that point as corresponding to a factor of either polarity, she may not treat it as corresponding to a factor stronger than the relevant extrema. The real importance of a dimension here is that further constraint beyond that of simple factors will develop as the case base grows.

I now turn to the other important feature of dimensions, their function in the representation of cases in a less abstract manner than factors. HYPO (Ashley 1991) and other dimensional approaches (Al-Abdulkarim et al. 2015; Atkinson et al. 2013; Chorley and Bench-Capon 2003) view case based reasoning as proceeding up a hierarchy, going from representations at the least abstract (most factual) level on the bottom to representations at the most abstract level on the top. In all of these approaches dimensions occur at the level (or a level) lower than the level of factors. For example, in Atkinson et al. (2013) dimension concerning how close a hunter is to capturing his prey, with different points for whether the prey was wounded, or if capture was inevitable, or if the hunter was merely in hot pursuit, is used to determine the presence of the factor "Caught" or the factor "Not Caught."

4.2 Dimensions as lower level representations

Dimensions have been used to represent the facts of a case in a less abstract manner than factors, which captures important aspects of and distinctions between cases that factors cannot (Ashley 1991; Atkinson et al. 2013; Bench-Capon 2017, sec. 7; Chorley and Bench-Capon 2005). I imported a similar hierarchy of higher and lower level factors into the reasons model using what I called "S-RULES" to represent rules of precedent that specify how to determine the presence or absence of a higher-level factor (Rigoni 2015). The representations on my two-tiered hierarchy will be too course-grained for many purposes, and I tried to address this previously (Rigoni 2015, sec. 5). Presently, the concern is whether my account of factors effects this approach.

It does in two ways. First, the approach to factors given here is equally applicable to C-Rules and S-Rules. Hence it provides the increased constraint discussed in Sect. 3.1 to the lower level S-Rules, which makes them more useful. Second, I do make use of points, which are a representation beneath factors. My points are essentially facts that may individually or in a groups correspond to a factor. The necessity of these non-factor representations to my approach does show some of the importance of lower level representations.

On the other hand, it's important to recognize that the usefulness of dimensions is not confined to lower levels on the hierarchy of representations. For any level of a hierarchy, a persuasive argument can probably be made for using dimensions, except for the very top level, which would have just two factors: (1) the plaintiff should win, and (2) the defendant should win.[17] This has recently been recognized in the literature, though this is a bit obscured by shifts in terminology. For example, Chorley and Bench-Capon (2005) have a layer of their representational hierarchy that involves "structured values," which are essentially dimensions at a higher level of the hierarchy. To illustrate, they have a structured value of using reasonable efforts to maintain a trade secret, which is supported to greater or less degrees by various factors, such as whether outsider disclosures were restricted. Atkinson et al. (2013, p. 47) consider a sequence of three factors at the level above that of their dimensions, where this sequence itself looks like a dimension but it's not referred to as such. Dimensions provide a richer representation than factors at every level of abstraction, and the question of when this richer representation is useful seems empirical, depending on the area of law being represented. Dimensions may be somewhat more useful at lower levels, where fine grain distinctions are more relevant and hence there are typically more representations needed.

Since there is no special connection between dimensions lower level representations, the introduction of dimensions into the reason model does not raise any new questions regarding the levels of representation. One can ask why the theory uses so few levels, but that question is not made any more or less pressing given the introduction of dimensions. The response from Rigoni (2015, sec. 5) is unchanged. Additional levels could be added following the strategy used to introduce S-Rules (rules used to determine the presence of a higher-level factor), which was to index the lower level reasons to the relevant upper level reasons and generate binding weighings between opposing sets of reasons for each level. The method of introducing dimensions at each level should be clear from this article.

The theory could be a portion of a complete theory of legal reasoning. Complete theories of legal reasoning will need to model every issue argued during a legal case, which goes well beyond issues where precedent can constrain. Moreover, they would go beyond what any single model of legal reasoning could address, whether

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[17] In Bench Capon (Al-abdulkarim et al. 2016) and (Garner 2004, p. 1592) the statement of the resolution at the final level is called the "verdict." While "verdict" is loosely used to refer to a judge's resolution of the issues in a non-jury trial (Garner 2004, p. 1592), strictly speaking this is incorrect. The term "verdict" technically refers to "a jury's finding or decision on the factual issues of a case" (Garner 2004, p. 858). The proper term for a "court's final determination of the rights and obligations of the parties in a case" is "judgment" (Bench-Capon 2017). This distinction makes possible that last request of the losing trial lawyer: a judgment notwithstanding the verdict (JNOV).

that model uses factors, rules, Bayesian reasoning, or some other approach, as I think the rest of this section makes clear. I conclude by discussing the different kinds of argument that occur during a legal case, as classified by the role of precedent. This provides an outline of how the reason model would need to be supplemented in a complete theory.

First, we must remember that many arguments heard in legal cases 0 are not "legal" at all. Parties argue about the inferences the court should draw from submitted evidence, including testimony, documents, video evidence, expert reports, physical objects, and so on.[18] Almost none of these arguments turn on the rulings of past cases. No judge cares whether a past court found a similar witness in similar circumstances to be unreliable. The appropriate models for this reasoning will not be distinctively legal and will cover a range of theories, such as Bayesian reasoning or coherence approaches, see Bench-Capon (2017) and the references therein. The reason model, or any similar model, will need considerable additions to accommodate such reasoning.

Second, we have arguments that are more distinctively legal, but where past cases are still largely irrelevant. For example, consider an objection that certain testimony is hearsay, or another one of the evidentiary objections typically raised during a trial. Very often rulings on this issues are made from the bench without briefing by the parties, though in theory the trial brief could address the issue if it was foreseeable before the trial. These are distinctively legal issues, as the judge is applying the law governing evidence, but the reasoning employed does not appear to be case based. Judges do not seem to be quickly scanning their memory for past cases with similar issues, although it's possible that is what is happening implicitly when they make these decisions. At the appellate level, these decisions are subject to review and the reasoning there looks case based—the appellate judges will look at what other appellate judges have permitted or prohibited in previous cases. Still, the deference given to the decision of the trial judge makes her ruling very significant to the outcome of the case. Hence a complete model of legal reasoning will need to address this type of reasoning at the trial level, where it looks like rule application without underlying cases to fill in the content of the rule, see Atkinson et al. (2013) for a model of rule application with underlying cases providing the content.[19]

Third, we have arguments that are distinctively legal and such that precedent is relevant, but not binding. In some instances, this is a function of the issue itself. For example, parties often argue vigorously over the proper amount of damages, and information about past damages awarded in similar cases is readily available.[20] However, damages are treated as factual determinations and can be made by juries, who are not influenced by or even aware of past awards. However, in a bench trial parties are free to use past damage awards to try and influence the judge's

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[18] Much interesting work on this topic can be found in Ashley and Walker (2013) and Walker (2007, 2009).

[19] Sentencing guidelines may work in a similar manner. They fix strict maximums and minimums, but then leave the judge complete discretion within those limits and past cases applying the guidelines do not function to narrow this range of discretion.

[20] See Jury Verdict Research Inc (2016), Klein (1991) and Shannon (2002).

determination of damage. Whatever influence those awards have, it cannot be binding precedent given the status of damages as a matter of fact. Similarly, criminal sentencing is not subject to precedential constraint.

In other instances, the lack of binding precedent is a function not of the issue, but the case base. Whenever there are no indistinguishable superior court cases the force of precedent is only persuasive, if available at all. In these cases, the judge may choose from rules extracted from treatises, inferior courts, courts outside the relevant judicial hierarchy, or craft her own rule. Even amongst these non-binding sources, there can be orders of preference. A system like ASPIC does an excellent job handling this kind of argument (Carey 2011), see also Bench-Capon and Sartor (2003), as it allows attacks on and preferences amongst sources of rules.

Still, frequently the justification for applying one rule rather than another lies in the values supported (and the degree of that support) by that rule as compared with those supported by the alternatives. This style of argument is well captured in Bench-Capon et al. (2012, sec. 13.1). Yet, parties in a case may argue about values as well so a complete theory would need to consider how the court reasons to an ordering of values. Grabmair (2016, 2017) has made headway on project this by treating past cases as establishing local orderings of values, which fix the ordering of values within a particular circumstance. This provides a kind of value precedent, though it's not clear whether, as a matter of jurisprudence, we should think of these orderings as binding. Still, whatever justifies the ordering of values can be argued about by the parties as well, which suggest a further level of a theory, for which another level of justifications can likely be constructed and argued about and so on. Eventually the argument will no longer turn on results in past cases but will instead become an exercise in moral reasoning to determine how values should be ordered or balanced. Just as legal reasoning can bottom out into non-legal, i.e., not distinctly legal, reasoning about factual inferences, it can "top out" in non-legal moral reasoning.[21]

Therefore, any model of purely case-based reasoning will need significant augmentation to capture the reasoning employed to decide a case; the reason model

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[21] Given the difficulties of modeling moral reasoning and the evidence that moral beliefs are very resistant to revision (Aramovich et al. 2011; Luttrell et al. 2016; Skitka 2010), especially in light of argument (Haidt 2001, 2010), it may be prudent for theories to treat the ordering of values (or whatever it is that is ordered at the highest level of the theory) as fixed before the case is argued. Each judge would have a constant ordering and ideally the theory would be able to apply that ordering to make predictions for cases before each judge. Realistically, one could use the widely accessible information regarding the judge's party affiliation as a proxy for their value orderings. The theorist would categorize the pool of judges according to political affiliation and construct a partial value ordering for each political affiliation, see Graham et al. (2009, 2011) Hirsh et al. (2010), pp. 655–56, Janoff-Bulman (2009) and Janoff-Bulman et al. (2008) for evidence of such value orderings using very abstract values. The political affiliation of the judge would then be encoded as part of the facts of the current case and the corresponding value ordering would be available, if needed, to generate a prediction for the case outcome.

Political affiliation represented in terms of less abstract attitudes or policy preferences does fairly well in predicting judicial decisions, see Heise (2002, sec. V.A.2) and citations therein, though these tend to be focused on very high level appellate cases that compose a small fraction of all cases. Still, if these attitudes seem resistant to argument, it would make sense to fix them within the theory instead of the more abstract moral values. Such a hybrid approach could allow the argumentative portion of the theory to deal with the mundane cases while the fixed values/attitudes can help resolve hard cases.

is no exception. The reason model requires different augmentation than some other models precisely because its purpose is different: it only attempts to capture a particular portion of legal reasoning, namely, the constraining force of precedent. If one were to extend the reason model, the natural additions would be additional levels of rules and corresponding reasons both below the S-Rules and above the C-Rules, as well as the incorporation of values to govern decisions to apply certain rules when no binding precedent exists. Here I must echo some of the sentiments of McCarty (Horty 2011; Horty and Bench-Capon 2012; Rigoni 2015), and stress that adding complexity is easy in theory but may be costly when put into practice.

As the preceding discussion illustrates, a complete theory of legal reasoning will need to use a number of different approaches, and it's not clear if the approach of the reason model rather than another approach should be used for modeling aspects of legal reasoning beyond its initial focus on precedent. Still, that is not a question that can be answered a priori; the ultimate standard is performance. We won't know if the added complexity is justified until we put the more complex theory into practice and see how much better (or worse) it does in handling a set of cases. Hopefully that challenge is taken up in future work.

5 Conclusion

This paper gives an account of dimensions in the reason model found in Horty (2017). The account is constructed with the purpose of rectifying problems with the approach to incorporating dimensions in (2015), namely, the problems arising from the collapse of the distinction between the reason model and the result model on that approach. Examination of the newly constructed theory revealed that the importance of dimensions in the reason model lies in their ability to establish weighings between reasons/factors of the same polarity and to so implicitly. This permits past cases to constrain future cases in ways they could not on the reason model with just factors. The paper then discusses how dimensions might be established from a case base and how dimensions that are incomplete in various way might be dealt with in the theory. It closes with comparisons to other work in the literature on AI and Law and suggestions for further improvements on the reason model.

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