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# USING DECISION DIAGRAMS TO EXPLORE, DOCUMENT, AND TEACH TREATMENT DECISIONS, WITH AN EXAMPLE OF THEIR APPLICATION TO A DIFFICULT PAINTING CONSOLIDATION TREATMENT

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## ABSTRACT

Decision matrices and decision trees are effective ways of sharing and communicating decisions. This paper suggests they be adopted for teaching, documenting, and understanding conservation treatments and illustrates this with a case study on the consolidation of a flaking painting by Mario Sironi. It demonstrates that doing nothing is simply another option that can be evaluated along with more active options, and that it may or may not be the best decision, depending on the decision criteria. This work also shows that different conservators can choose very different options for treatment while being completely objective in their judgements.

## RÉSUMÉ

Les matrices et les arbres de décisions sont des moyens efficaces pour partager et communiquer les décisions. Cet article suggère que ces procédés soient adoptés pour l'enseignement, la documentation et la compréhension des traitements, ce qu'il illustre par une étude de cas portant sur la consolidation d'un tableau de Mario Sironi qui s'écaillait. Il démontre que ne rien faire est tout simplement une alternative qui mérite d'être évaluée au même titre que d'autres options plus actives, et que cela peut être ou non la meilleure décision en fonction des critères de décision retenus. Ce travail montre également que différents restaurateurs peuvent choisir des options très différentes pour le traitement, tout en faisant preuve de la plus grande objectivité dans leurs jugements.

## RESUMEN

Las matrices y árboles de decisión son formas efectivas de compartir y comunicar decisiones. Este artículo sugiere que estas formas

## INTRODUCTION

In 2008, CESMAR7 organized a series of case studies on the consolidation of paintings, called Open Studio projects, which were delivered as papers at its 4th annual conference in 2009. We were part of a team of conservators and conservation scientists that presented a project on a 1930s painting by Mario Sironi (Buzzegoli et al. 2009). The Sironi painting was executed in a theatrical gouache medium and several areas were disintegrating into small (~1 mm) and thin (~0.1 mm) flakes. Preliminary tests on mock-ups showed that conventional consolidant treatments would darken these paints or change their gloss. As the team discussed treatment options and sub-options – some well understood, others less so and each imperfect in its own way – the lead conservator (Rossi-Doria) realized that the project had become not only an opportunity to research methods of consolidation, but to research methods of structuring the decision process itself. The consolidation theorist (Michalski) had just completed a review of decision theory literature for lectures in the ICCROM course *Sharing Conservation Decisions*. It was an ideal opportunity to discuss, and to test, decision theory in practice.

The full record of the case study itself and the numerous tests of consolidants on mock-ups are reported in the CESMAR7 proceedings (Buzzegoli et al. 2009). Here we focus on the decision-making tools and some of the novel conclusions that emerged during their application.

## PROBLEMS CAUSED BY HIDDEN OR UNRECORDED DECISION-MAKING

### The problem of teaching treatment decisions

For the senior practitioner, the treatment idea often emerges fully formed from a sea of knowledge and experience. Faced with mentoring younger colleagues, there has been a constant problem in trying to explain clearly the thinking behind such decisions. How to show the logical connections from one small decision to another, how to explain the numerous paths considered but abandoned and how to explain how a selection was made from among options when none of them was perfect. Not to mention the times when the inquiring student uncovers decision paths in the mentor's mind that are now hidden by long habit, or even plausible decision paths

pueden adoptarse para la enseñanza, la documentación y para una mejor comprensión de los tratamientos de conservación, y lo ilustra con un estudio de caso sobre la consolidación de una pintura escamada de Mario Sironi. Demuestra que no hacer nada es simplemente una opción más que se puede evaluar junto con otras opciones más activas, y que ésa puede ser o no la mejor decisión dependiendo de los criterios de decisión. Este trabajo también muestra que diferentes conservadores pueden elegir opciones de tratamiento muy diferentes y a la vez ser completamente objetivos en sus juicios.

that were never considered. Is there a better way than mere words and lists to share the decision?

## The problem of sharing treatment decisions inside and outside the profession

Our profession is well aware of the need to share treatment decisions within its borders, as well as with others (Ramsay-Jolicoeur and Wainwright 1990), but one of the first problems, perhaps a casualty of the lack of time, or perhaps the lack of humility, is the sharing of information about alternative treatments that were not chosen.

The field of medicine is holding a similar discussion at the moment: can its two most important trends, evidence-based medicine (EBM) and client shared decision-making (CSDM) be reconciled (Barrat 2008)? Resistance originates in the assumption that evidence-based medicine is both objective and complete, so a client's preference is irrelevant. Aside from the fact that even objective decisions can find multiple optimal solutions (more about that later) the bigger issue is that many key elements of the decision depend on the patient's judgements and preferences. As we well know, the same issue arises with heritage treatment decisions.

## The problem of documenting decisions for the future and of completeness

Our profession is obsessed with the completeness and permanence of our treatment records and it is easy to fault historical records that might consist of just a single such as : "1934: lined." On the other hand, private professionals scoff at the encyclopaedic proposals and reports often produced by institutional conservators. There are three kinds of "completeness" that we are pursuing here.

The first kind of completeness refers to the description of what the final treatment consisted of. Is this adequate for a future understanding of what was done? The profession is well served here.

The second form of completeness is the future understanding of why what was done was done. This is the record of all the options considered and an explanation of the criteria used to select what was thought to be the best option. Both private and institutional conservators need cost-efficient tools to achieve this second kind of completeness. We suggest that this form of completeness is best served by decision-making diagrams.

The third form of completeness is the hope that all possible information was considered in the decision. This hope is illusory. Decisions are never complete in this sense; they operate within what is called "bounded rationalism." All the information in the world that can be assembled is itself incomplete and the portion of this that we can actually assemble is far less.

## DECISION DIAGRAMS AND DECISION ARITHMETIC

There are two kinds of decision diagram, reflecting two chronologies of decisions: single and sequential. Practical decision diagrams, such as the one developed for the Sironi case study, are a mixture of both.

### Single decisions: the decision matrix

The simplest decision diagram is a matrix (or call it a table). It has a list of options on one axis, and a list of criteria on the other, as in Table 1. The decision matrix forms the building block of many management and engineering tools, under such names as a grid analysis, decision matrix analysis (DMA), multi criteria decision analysis (MCDA) or multiple attribute theory (MAUT). Theoretical refinements in specific tools focus on scoring and weighting. Numerous free tools and guides can be found on the web under these names, but for our purposes a simple written table is enough.

**Table 1**
Example of a simple decision matrix with scores on a five-point scale, where 1 is low and 5 is high. By "appearance" is meant immediately after treatment; by "stability" is meant estimated change in appearance after 100 years and by "speed" is meant the total labour cost

| | Appearance | Stability | Speed | Total score | Decision |
|---|---|---|---|---|---|
| **Option A** | 1 | 5 | 4 | 10 | |
| **Option B** | 4 | 4 | 2 | 10 | |
| **Option C** | 5 | 1 | 5 | 11 | ok |

**Option A** (quick, very stable, but darkens immediately)
**Option B** (invisible but very laborious, may yellow slightly with time)
**Option C** (do nothing)

### "Killer" criteria: musts vs wants

Illustrated in Table 2 is the result of making a certain score on a criterion mandatory. If it is not satisfied, it kills the option regardless of the total score. In their classic text, Kepner and Tregoe (1976) called these criteria "musts" as compared to "wants." In our field, for example, a minimum level of stability is often a "must." A minimal change in appearance is also a "must." Table 2 shows the addition of a "fail" notation to the column if the minimum criterion is not met. The best option is now selected from the short list of options that have no fails. Note that in the example of Table 2, the "do nothing" option fails due to its poor score on "stability."

**Table 2**
Example of the same decision matrix as Table 1, except that "stability" must score 3 or above. In this scheme, option C "do nothing" fails. The other two options are equally good, but balanced differently

| | Appearance | Stability | Speed | Total score | Decision |
|---|---|---|---|---|---|
| **Option A** | 1 | 5 | 4 | 10 | ok |
| **Option B** | 4 | 4 | 2 | 10 | ok |
| **Option C** | 5 | 1 fail | 5 | 11 | fail |

### Distinguishing 'philosophies' from criteria and options

Our conservation treatment decisions have become full of mandatory criteria (needs) such as "reversible", "permanent" and "no visible change". If one defines too many needs too stringently, then no treatment option passes. It can seem as if doing nothing – minimal intervention – emerges as the winner by default. As seen in Tables 1 and 2, however, doing nothing is not a special kind of option in a higher decision universe; it is simply another option, which can be evaluated by the same criteria as all other options. If we recognize the criterion of stability to actually mean "minimum change of appearance in 100 years" then we must judge doing nothing in terms of "the state of the object in 100 years if nothing is done." In the case of the Sironi painting, it was judged that the paint layer, which already showed areas of small flake loss, would lose substantially more matter over the years if nothing was done. So doing nothing failed as an option.

In a more literate argument, Villers (2004) makes the same critique of minimal intervention. "Appearance" in Viller's text goes beyond the simple color change caused by a consolidant, it speaks of the appearance of the painting as a whole aesthetic object. But we are also invoking this subjective whole when we judge the expected change to the painting if it is consolidated, or not.

Minimal intervention can be a philosophy or at least a system of values if one claims to be a fatalist, or a non-interventionist, or a sceptic about human meddling, but one cannot then conclude that therefore this particular painting will be in better condition in 100 years than if some action is taken.

**Table 3**

A decision matrix with weighting. "Appearance" and "stability" are considered twice as important as "speed"

| | Appearance | Stability | Speed | Total score | Decision |
|---|---|---|---|---|---|
| **weight** | 2 | 2 | 1 | | |
| **Option A** | 1 × 2 | 5 × 2 | 4 | 16 | |
| **Option B** | 4 × 2 | 4 × 2 | 2 | 18 | ok |
| **Option C** | 5 | 1 fail | 5 | 16 | |

In decision theory, a probabilistic (risk management) perspective can (and should) be considered where useful. For example, the option of "waiting and taking a chance a new solution will appear soon with excellent scores on all criteria" might be considered. Maybe there is a 10 percent chance that every 10 years a solution like this will appear. In 50 years, the odds would be even and in 100 years an odds-on certainty (but much too late!). An intuitive version of this calculation may be behind the convictions of many "minimalists." But what is the rate at which new polymers appear that can be used in consolidation, have known aging behaviour, good working properties, realistic application methods and which are a categorical improvement on what has come before? No better than 10 percent per decade, at least. The progressive flaking was certain to appear in 30 years, maybe less. But the decision was taken based on what was known now.

## Different weights for different criteria

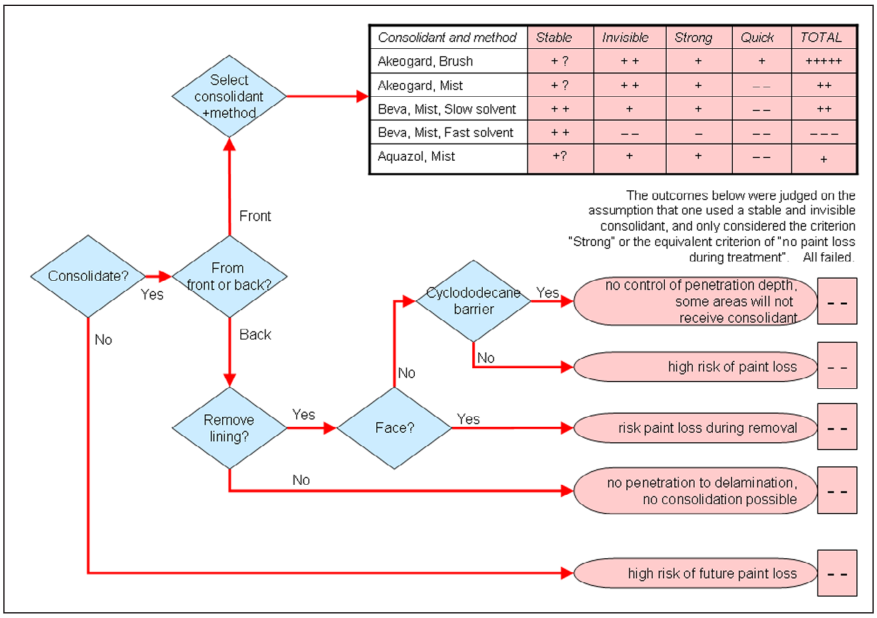
To emphasize one criterion more than another, such as appearance over cost, and given the same five point scale, one uses a weighting factor as in Table 3. This is not the same as a mandatory minimum, but it can have a similar effect. Weighting factors are often adjusted after the fact to justify a decision already made and while this may be seen as an abuse of the objectivity of decision-making, it can also be seen as a way of calibrating the criteria. It makes clear to everyone how the criteria must be weighted in order to justify the decision, which serves the valuable purpose of informing the decision-makers of the logic that must be implicit in their otherwise instinctive decision.

## Sequential decisions: finding the right path on a decision tree

> "I shall be telling this with a sigh
> Somewhere ages and ages hence:
> Two roads diverged in a wood, and I –
> I took the one less traveled by,
> And that has made all the difference."
>
> Robert Frost (1874–1963), The road not taken,
> in *Mountain Interval*, 1920

Words like "path" and "road" occur frequently in informal descriptions of decision-making and decision trees are simply a formal diagram of those paths. They may also be known as flow charts. The Sironi case study decision tree is shown in Figure 1. Each diamond, or box, or oval, or matrix, is called a node. There are many different styles of drawing nodes and entire libraries of node shapes for various purposes, but that is not important. All that matters is that each node is a separate decision and that the big decision of how to treat the painting is actually a sequence of smaller decisions.

In our world, the logic of decision trees is often determined by physical reality. For any real object, the first decision is whether to do anything (in the physical world). In the case of the Sironi, once the decision had been taken to do something, the next decision was whether to consolidate from the front or from the back – there are only two sides to a painting! It may seem trivial, but the human mind does not always remember that a certain issue (along the same lines as, "will cyclododecane do what we want it to do?") only applies to options where we approach consolidation from the back of the painting. We considered the back approach seriously at the beginning, since it seemed such an obvious way to avoid going through the delicate face to get at the delamination. Hence all the paths from that branch in our diagram (Figure 1), all of which failed on careful examination of the outcomes.




| *Consolidant and method* | *Stable* | *Invisible* | *Strong* | *Quick* | *TOTAL* |
|---|---|---|---|---|---|
| Akeogard, Brush | + ? | + + | + | + | +++++ |
| Akeogard, Mist | + ? | + + | + | – – | ++ |
| Beva, Mist, Slow solvent | + + | + | + | – – | ++ |
| Beva, Mist, Fast solvent | + + | – – | – | – – | – – – |
| Aquazol, Mist | +? | + | + | – – | + |

**Figure 1**
The decision diagram developed during and after the planning of the consolidation of the Sironi painting

## Outcomes

The final node is the outcome: the predicted state of the painting, and its score against the criteria. Each path from start to outcome is an option, but now we can see how options are related. Are they part of the same family, like the "consolidate from the back of the painting" branch, or do they belong to some other family?

The outcomes of the "consolidate from the back" branch were judged in various ways: some by prior experience, some by reasoning and some by testing. Many experiments with cyclododecane were performed on mock-ups to see if the front surface could be sealed without blocking the delaminated regions. It was discovered that cyclododecane can be misted, but that did not solve the problem: depth of penetration cannot be controlled with the finesse necessary to seal 0.1 mm flakes without blocking the region of delamination.

Plus and minus signs were used in the diagram The result is the equivalent of a "bad to good" scale of -2 to +2. The results are sorted exactly as would occur with a 5-point scale from 1-5, but it reminds users more intuitively whether the judgement is literally bad (-) or good (+) and it forces the choice of something other than the neutral center.

### Previous use of decision diagrams in conservation

Other conservation authors have introduced decision trees. Ashley Smith (1999) devotes a chapter to this and Caples (2000) follows with a full page example, but these are slightly different decision trees, used to trace compound probabilities along each path, common in the fields of finance and failure analysis. They may interest collection managers but not bench conservators. Strang (2003) developed a decision tree in the sense of a flow chart to help archives direct the steady stream of incoming audio-visual records. The diagrams used were closest to that of Strang's, but at the end of each path is added the notion of a scored outcome. Diagrams with "boxes and arrows" come in many dialects – all that matters is that they be meaningful to the intended users.

## WHEN MANY OPTIONS ARE EQUALLY GOOD

If two conservators or two schools of thought reach different treatment decisions, is one of them mistaken or being "subjective"? Not necessarily. Different and legitimate decisions can be made for two reasons: bounded rationality and the trade-off problem.

Bounded rationality means that the knowledge available for any decision is finite in principle and usually very limited in practice. Different conservators will always bring different (but probably overlapping) collections of knowledge to their decisions. These issues have already been raised in proceedings organized for this field by Baer (2002).

The trade-off problem can be seen in the simple case of Table 2: two options achieve the same score, though with a very different balance of strengths and weaknesses. Consolidating treatments tend to trade-off strength and appearance. Or appearance and treatment cost. Although one might argue that the example of Table 2 occurs only because the criteria or scoring are simplistic, complex mathematical models of MCDM in design problems with only one pair of trade-offs show a whole family of equally good solutions emerging, called the Pareto set or trade-off function (Indraneel and Dennis 1996). Add to that several pairs of trade-offs, and it is a wonder that consensus emerges at all in any field. In fact, it is probably habit and social pressures that drive most consensus, rather than the inevitability of objective processes.

## SOME GUIDELINES FOR MAKING DECISION DIAGRAMS

### Doing nothing is always an option

Doing nothing ("benign neglect") is always an option in the diagram and worth considering explicitly. It may (or may not) be one of the best options.

### It is alright to mix objective and subjective judgments

Some conservators might balk at mixing technical criteria such as degree of yellowing in the future with subjective criteria such as overall change in appearance immediately after treatment, but in all practical decision-making, subjective scales are the only scales that can be commensurate across mixed criteria. The technical scores are translated into subjective scores, not vice versa (e.g., to compare degree of yellowing in the future with change in appearance after treatment, both must be judged in terms of loss of value to the artwork). Yes, it is uncertain, but it is the same process that we all follow in our heads when we make treatment decisions without diagrams. The authors simply propose that we share this mental arithmetic and its conversions and weightings as explicitly as possible.

### Simple software to help drawing decision diagrams

The most important feature for saving huge amounts of time drawing a decision tree on your computer is "smart connectors". These are lines that stick at each end to the node shape and allow you to drag the node to a new location without losing the connectors. Microsoft Word and Powerpoint both have such connectors in their drawing toolbars, as do most design and drawing software.

A powerful and free software is Cmap, from http://cmap.ihmc.us/. Although intended for concept mapping, one can certainly use the tool to construct decision trees, since the branching structure is the same.

## CONCLUSION

Decision diagrams illustrate not only the path to the final decision, but they make explicit all the paths that were considered but rejected, and they make explicit the reasons, or lack of reasons, for those rejections. They also imply by omission all the options that were not considered at the time. The authors believe it is not the particular choices made that characterize the treatments of an era, so much as the range of options available, the range considered, and the criteria employed.

Decision theory shows that radically different treatment choices by different conservators or different schools do not imply that someone is being subjective, arbitrary, or mistaken. They occur when no single option gives the highest score in all criteria. Trade-offs will give rise to sets of equally optimal decisions.

The economic crisis has provoked a back-lash against decision tools by the highly experienced users of these tools in banking (Kay 2010), but the limitations and abuse of models has always been recognized, especially for highly complex systems involving people. Within the spirit of this paper, it is not suggested that decision diagrams automate decisions, merely that they help us to think through complex decisions and to share them transparently.

Admittedly, the decision diagram used was only a rough sketch on paper during the treatment and not always integral to the thinking of the team, but it did serve at key moments to give the leader a sense of what had been achieved and how. Most importantly, it gave the sense that the best possible decision for that painting at that moment in time had been taken.

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