4-1-2011

Building a Decision Aid Right-side-out

Barry F. Anderson
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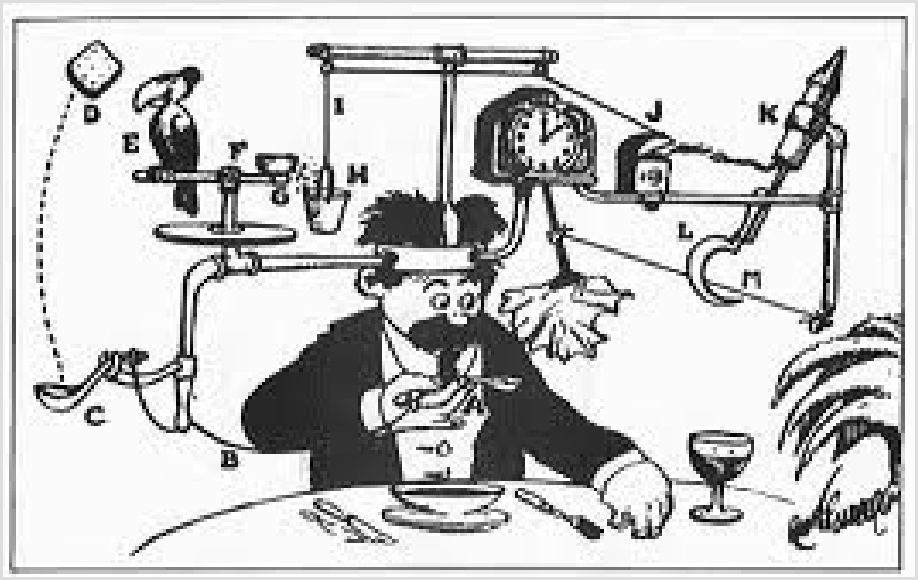


BUILDING a DECISION AID
RIGHT-SIDE OUT

Barry F. Anderson
Department of Psychology
Portland State University

The Thesis

- Decision aids are human-machine systems that, ideally,
  (a) represent rationally the underlying logic of the **problem**, *AND*
  (b) take into account the bounded rationality and the irrationality of the **user's mind**.
- Decision aids that have been around the longest were built by professionals, for professionals. They represent the underlying logic of the problem well but are not widely used.
- Some aids have been developed recently for the popular market but don't score well on *either* criterion. **Wise Decider** is being developed with both criteria in mind.

- People often make important decisions badly.
- Some of the simplest features of decision analysis can improve decisions.
- People rarely use decision analysis.
- Why, and what can be done?

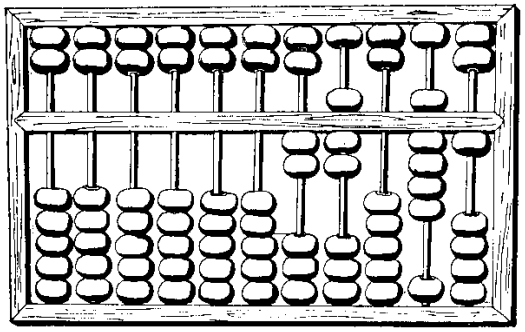
Some of the Simplest Features of Decision Analysis Can Improve Decisions

Even low-tech decision analysis…

- Provides external memory
- Compares alternatives
- Considers outcomes
- Analyzes outcomes into attributes (decision tables)
- Analyzes outcomes into futures (decision trees)
- Separates facts from values

DA Provides External Memory I

For example, Japanese outperform other cultures in calculation by using or thinking in terms of abacuses.



Hatano, G. (1982). Learning to add and subtract: A Japanese perspective. In T. P. Carpenter, J. Moser, M., & T. A. Romberg (Eds.), *Addition and Subtraction: A cognitive perspective.* Hillsdale, NJ: Lawrence Erlbaum. P. 217.

DA Provides External Memory II

- *A priori* decomposition. Decision analysis analyzes the problem into simpler components prior to judgment and then combines the analytic judgments mathematically.
- *A posteriori* decomposition. Statistical (bootstrap) models analyze, after the fact, judgments made holistically.

  Even *a posteriori* models outperform the decision makers on whose judgments those models are based, by providing external memory and removing the randomness from those judgments, thus "raising the decision makers by their own bootstraps."

Dawes, R. M. (1979). The robust beauty of improper linear models in decision making. *American Psychologist,* **34**, 571-582.

DA Provides External Memory III

Presentation	Testing: On Paper: Anything else?	Testing: In Head: Anything else?
 "Rabbit"	100% saw duck	0% saw duck
 "Duck"	100% saw rabbit	0% saw rabbit

Reisberg, D. (1996). The non-ambiguity of mental images. In C. Cornold, R. Logie, M. Brandimonte, G. Kaufman, & D. Reisberg (Eds.), *Stretching the Imagination: Representation and transformation in mental imagery.* NY: Oxford U. Press.

DA Requires Comparison of Alternatives I

Without comparison:

A 7/36 chance to win $9 is rated 9.4.

A 7/36 chance to win $9 *and a 29/37 chance to lose 5 cents* is rated 14.4.

Slovic, P. (1985). Violations of dominance in rated attractiveness of playing bets. *Decision Research Report 85-6.* Eugene, OR: Decision Research.

DA Requires Comparison of Alternatives II

When a single case is evaluated, judgments of a rape victim's responsibility are higher for a virgin than for a divorcee.

Birnbaum, M. (1982). Controversies in psychological measurement. In B. Wegener (Ed.), *Social Attitudes and Psychological Measurement.* Hillsdale, NJ: Erlbaum. Pp. 401-485.

Kahneman, D., & Miller, D. T. (1986). Norm theory: Comparing reality to its alternatives. *Psychological Review,* **93**, 136-153.

Hsee, C. K. (1996). The evaluability hypothesis: An explanation of preference reversals between joint and separate evaluation of alternatives. *Organizational Behavior & Human Decision Processes,* **46**, 247-257.

DA Requires Comparison of Alternatives III

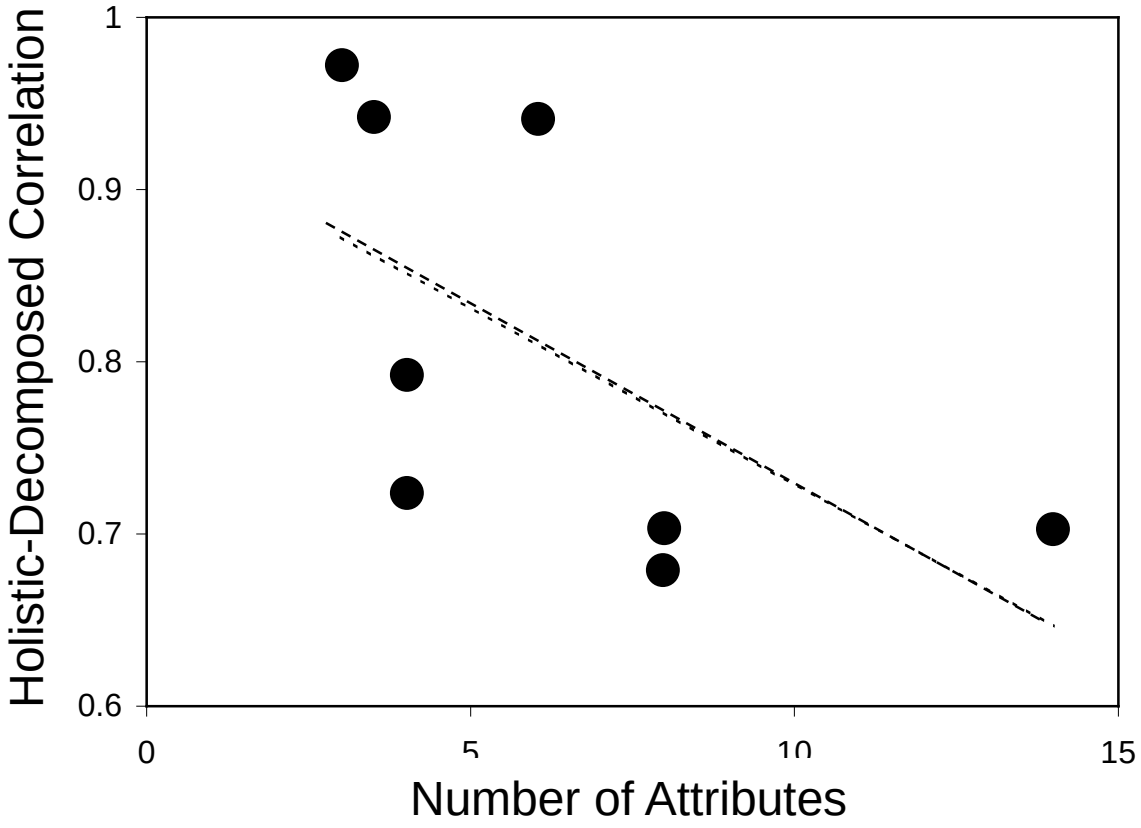
We tend to “throw good money after bad”, favoring alternatives for which we have already incurred substantial costs, even though these costs were incurred in the past and *are thus necessarily the same for all alternatives*.

DA Considers Outcomes

	Pass	Fail	Don't Know
Buy vacation	54%	57%	32%
Not Buy Vacation	16%	12%	7%
Pay $5 to decide later	30%	31%	61%

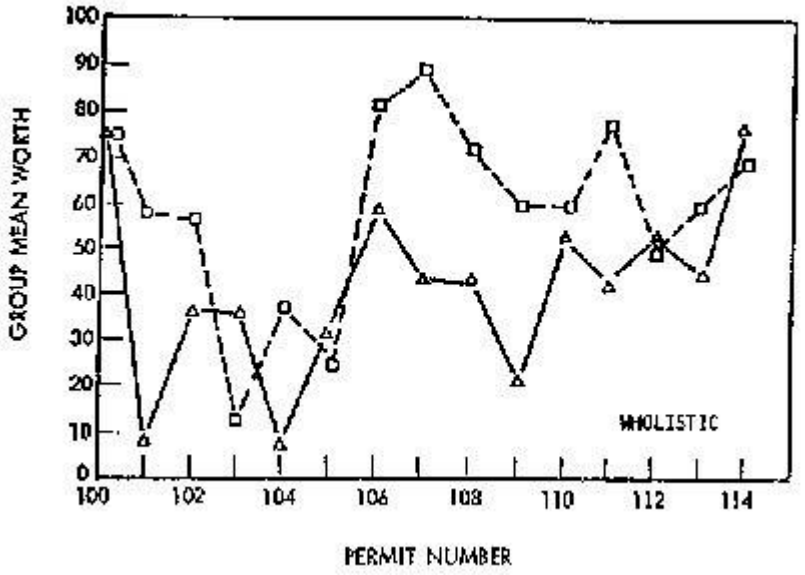
Tversky, A., & Shafir, E. (1992). The disjunction effect in choice under uncertainty. *Psychological Science,* **3**, 305-309.

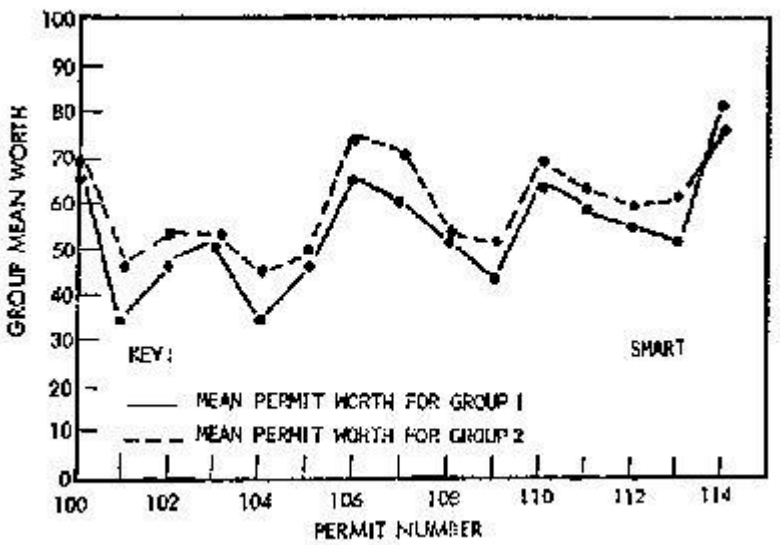
DA Analyzes Outcomes into Attributes I



von Winterfeldt, D., & Edwards, W. (1986). *Decision Analysis and Behavioral Research.* Cambridge: Cambridge U. Press. P. 364

DA Analyzes Outcomes into Attributes II





Gardner, P. & Edwards, W. (1975). Multiattribute utility measurement for social decision making. In M. F. Kaplan & S. Schwarz (Eds.), In M. F. Kaplan & S. Schwarz (Eds). *Human Judgment and Decision Processes.* NY: Academic Press.

DA Analyzes Outcomes into Possible Futures (Correctly)

Superadditivity. Probabilities at an event node sum from slightly over 1.00 for 2 events to around 3.00 for 16 events.

Explanation. Events not in attention seem to be underweighted. “Other” underweighted in fault tree.

DA Separates Facts from Values
(& permits distributed decision making)

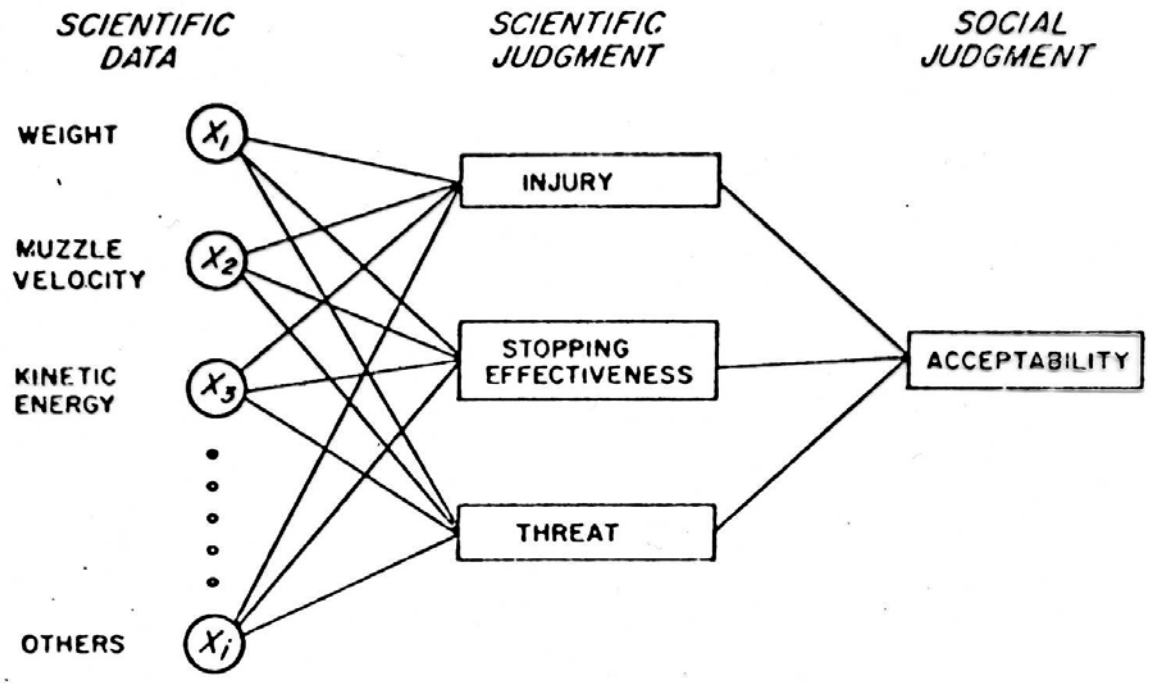


Fig. 1. A pictorial representation of a framework that combines scientific facts with social values.

Hammond, K. R., & Adelman, L. (1976). Science, values, and human judgment. *Science*, **194**, 389-396.

Conclusion

- The greatest net benefit may come from simple changes that represent more rationally the underlying logic of the **problem** without becoming so complex as to lose touch with the bounded rationality and the irrationality of the **user's mind**.
- Overall Quality = Verisimilitude X Useability

"Better the half than the whole."

- Chinese proverb.

- ✓People often make important decisions badly.
- ✓Some of the simplest features of decision analysis can improve decisions.
- People rarely use decision analysis.
- Why, and what can be done?

People Rarely Use Decision Analysis

Resistance to Bootstrap Models

•Over 50 years of demonstrations of the superiority of bootstrap models to the judges they model have had almost no effect on the practice of human judgment! Why?

•Models threaten egos and pocketbooks.

•Models are less politically impressive.

•Statistical evaluation reveals error, while intuitive evaluation conceals error.

Dawes, R. M. (1979). The robust beauty of improper linear models in decision making. *American Psychologist,* **34**, 571-582.

Resistance to Checklists in Medicine

In 2001, Peter Pronovost, an M. D. at Johns Hopkins, introduced a checklist for reducing infections when putting a line into a patient. In the first two years of using the checklist, the 10-day line infection rate went from 11% to 0%; the number of deaths dropped by 8; and the costs dropped by $2,000,000.

Gawande, A. (2007). The Checklist. *The New Yorker.* Dec. 10. Pp. 87-95.

Pronovost also introduced a checklist for caring for patients on mechanical ventilation. In the first year, the percentage of patients who failed to receive the recommended care dropped from 70% to 4%; the occurrence of pneumonia fell by 25%; and 21 fewer patients died.

In the state of Michigan, a checklist saved 1500 lives and $75,000,000 in the first 18 months.

What was the reception?

- There were few additional takers.
- Some physicians were offended.
- Some doubted the evidence.
- Some said, “Forget the paperwork. Take care of the patient.”

Resistance Among Decision Scientists

"What do *you* do for a living?"

"Study decision making."

"Then you can help me. I have some big decisions to make."

"Well, actually…."

Slovic, P., Fischhoff, B., & Lichtenstein. S. (1977). Behavioral decision theory. *Annu. Rev. Psychol.*, **28**, 1-39.

Resistance at NSF and NIH

The National Science Foundation and the National Institutes of Health refused to use decomposed ratings for reviewing their proposals, although the changes were

- Recommended by a leading decision researcher,
- Well supported by research, and
- Simple to implement.

Arkes, H. R. (2003). The nonuse of psychological research at two federal agencies. *Psychological Science*, **14**, 1-6.

The responses?

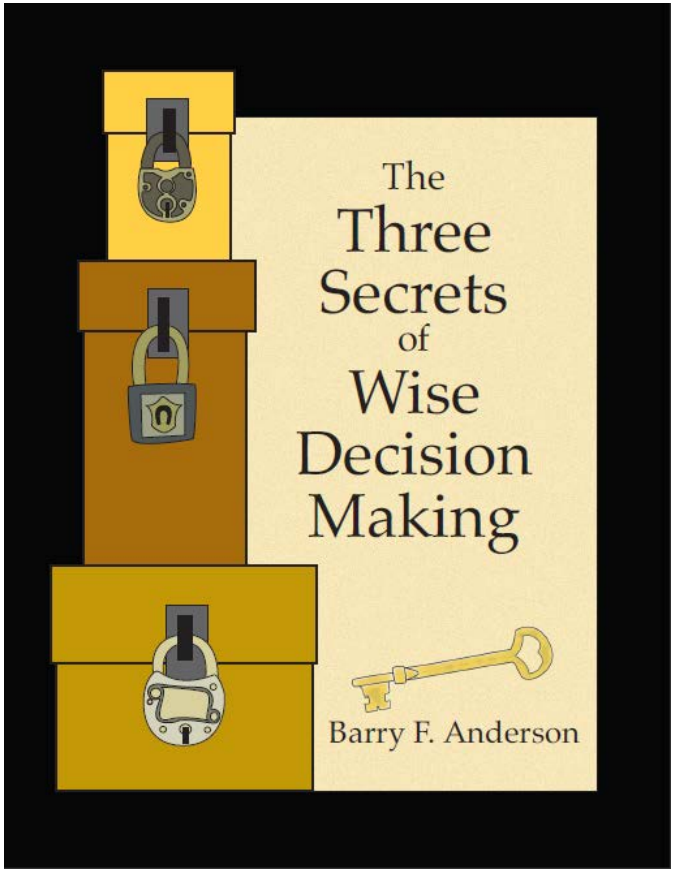
“We don’t want any criteria.”

“[This suggestion] causes less agreement and consensus than we would like around here.”

“No psychologist is going to tell me how to evaluate proposals.”

A Personal Experience of Resistance Among Instructors

- Editors loved *The Three Secrets.*
- BUT marketing departments couldn't find enough courses to justify financially the decision to publish.



A Resource-Allocation Perspective

The National Institutes of Health has a budget of $30,000,000,000 a year to fund *medical discoveries*.

Yet work on using checklists in medicine has already *saved more lives than that of any medical discovery in the past decade.*

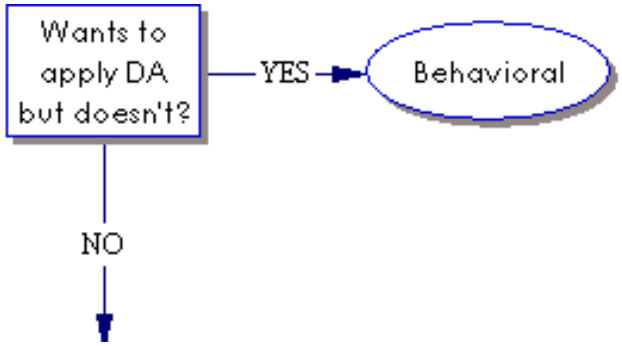
Research on putting knowledge about decision making into practice should be similarly cost-effective.

- ✓People often make important decisions badly.
- ✓Some of the simplest features of decision analysis can improve decisions.
- ✓People rarely use decision analysis.
- Why, and what can be done?

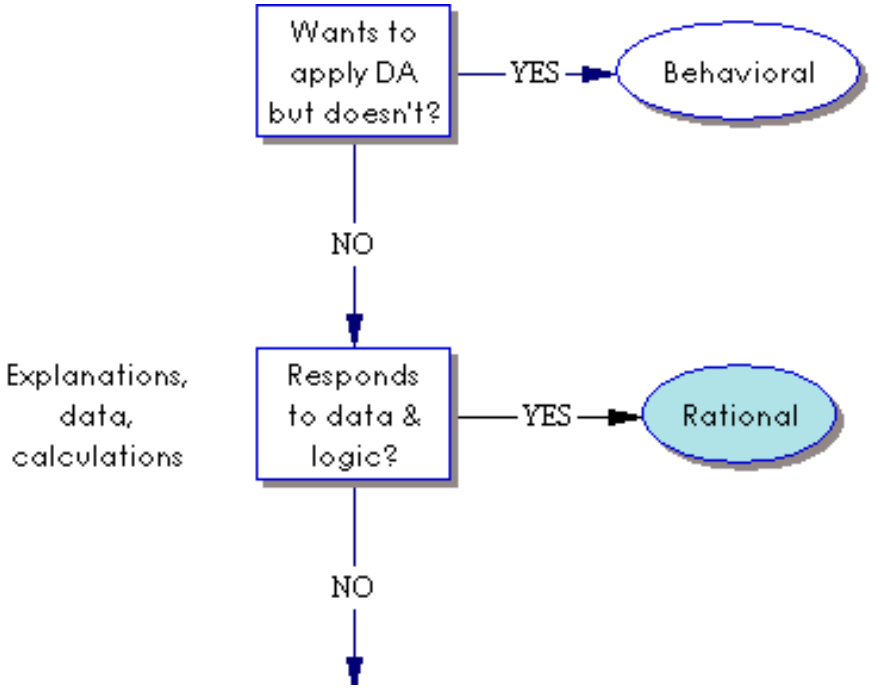
Why and What Can Be Done?

Diagnosis of Causes of Problem

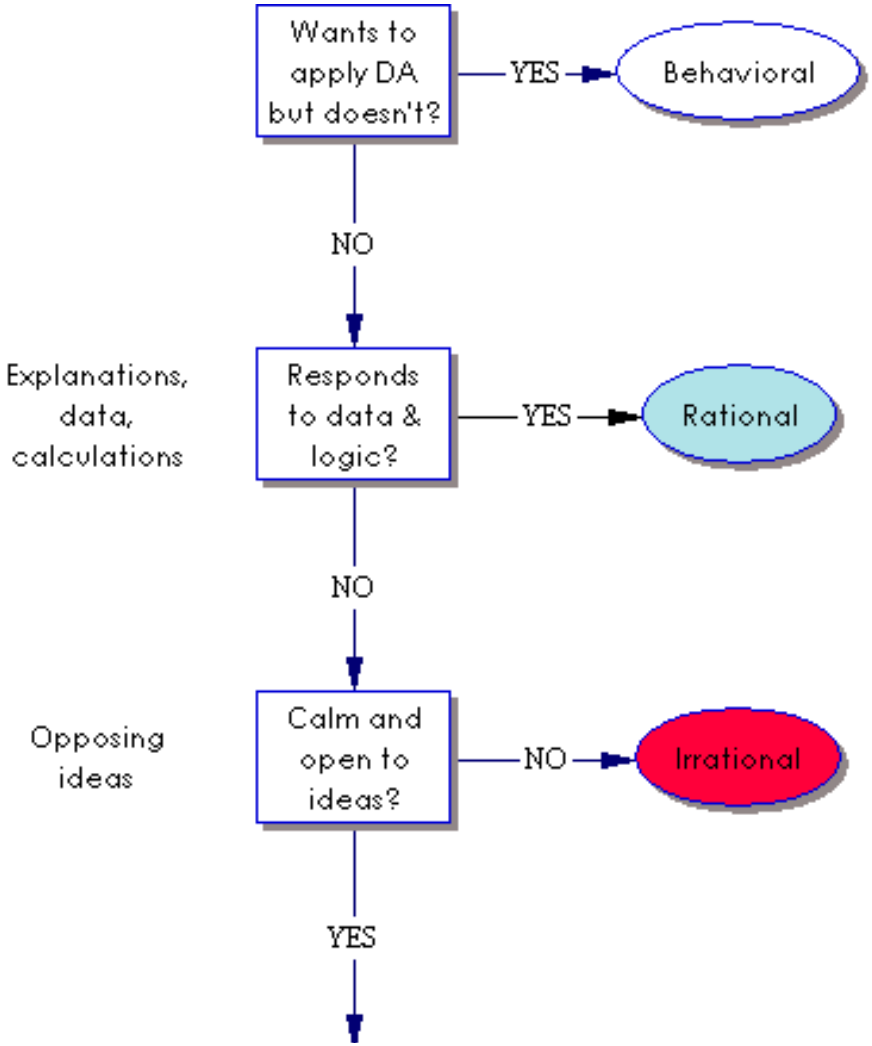
Causes for Resistance to Decision Analysis



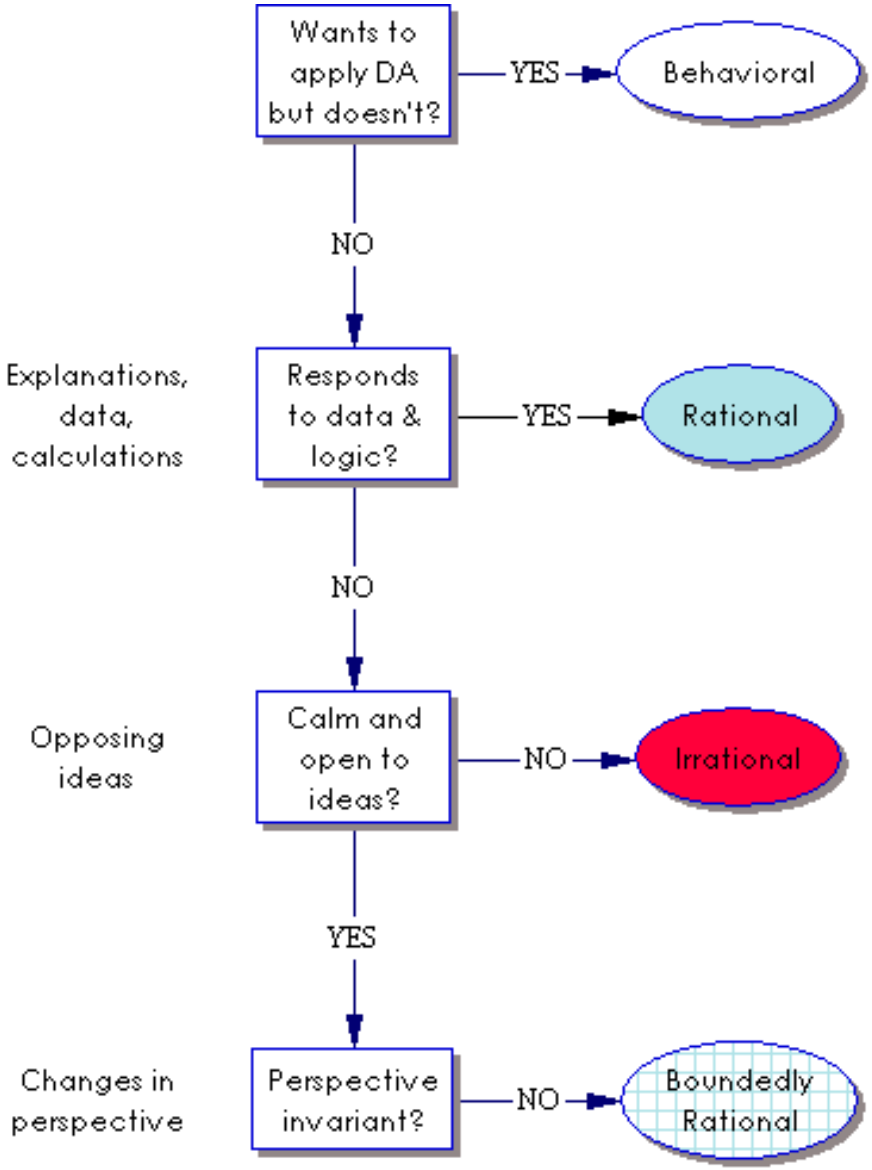
Causes for Resistance to Decision Analysis



Causes for Resistance to Decision Analysis



Causes for Resistance to Decision Analysis



Examples of Behavioral Reasons

- Not thinking to use DA
- Insufficient skills to implement DA
- Insufficient motivation to implement DA.
- Insufficient authority to implement DA

Examples of Rational Reasons

- *Diagnosticity.* "It's not likely to make any difference." (overconfidence)
- *Value of information.* "The difference it makes isn't likely to justify the costs."
- *Political externalities.* "An improved decision would incur political costs."
- *Personal externalities.* "An improved decision would incur personal costs."

Enhanced Benefits Not Likely to Be Seen as Justifying Increased Costs to the DMer

Subjects with a decision aid did not use more information than subjects without one. Effort is weighted more than accuracy, probably because feedback on effort is both more immediate and more tangible.

Todd, P. & Benbasat, I. (1992). The use of information in decision making: Investigation of the impact of computer-based decision aids. *MIS Quarterly*, September.

Examples of Intuitive Reasons

- *Cognitive position bias.* "The answer is perfectly clear without any DA." (*E.g.,* availability, similarity.)
- *Decision style bias.* "That's not the way I like to think about decisions. It's difficult for me to have confidence in the results." (*E.g.*, discussion, stories, reasons, images.)

Examples of Irrational Reasons

- *Motivated position bias.* "There's no way I'm going to put my favored alternative at risk."
- *Motivated process bias.* "There's no way I'm going to yield any control over the decision process."

Decision *Training*
May Not Be the Answer

Decision Training May Not Be Very Effective

- High school students often can't deal effectively with problems requiring abstract thinking. Renner, J. W., & & Stafford, D. G. (1972). *Teaching Science in the Secondary School.* NY: Harper & Row.
- As many as 50% of incoming college students operate below Piaget's level of formal operations. Gray, R. L. (1979). Toward observing that which is not directly observable. In J. Lochhead & J. Clement (Eds.), *Cognitive Process Instruction.* Philadelphia: Franklin Instit. Press. Pp. 217-228.

GOFER

The Most Herculean Attempt Yet to Teach Decision Making

- Goals clarification,
  Option generation,
  Fact finding,
  Consideration of Effects,
  Review & Implementation

- 40-50 contact hours spaced over at least 1 year
- *Basic Principles of Decision Making, Decision Making in Practice, 2* student workbooks, and a teachers' manual
- Two-four-day workshops sponsored by State Education Departments in Australia.

Mann, L., Harmoni, R., & Power, C. (1991). The GOFER course in decision making. In J. Baron & R. V. Brown, Eds. *Teaching Decision Making to Adolescents.* Hillsdale, NJ: Erlbaum. Pp. 61-78

Evaluation of GOFER

- Improved confidence in decision making.
- Improved verbal knowledge of the course material.
- Yet no difference on any of the G, O, F, E, or R steps in decision making.

Beyth-Marom, R., & Fischhoff, B. (1991). Teaching decision making to adolescents: A critical review. In J. Baron & R. V. Brown, Eds. *Teaching Decision Making to Adolescents.* Hillsdale, NJ: Erlbaum. Pp. 34.

Independence of Verbal Knowledge and Performance

In four tasks and two studies, practice improved only utilization of the correct rule, and explanation improved only the ability to articulate the correct rule.

- *Study 1.* Maximize sugar production by changing number of workers; achieve a target social response by changing social behavior.

  Berry, D. C., & Broadbent, D. E. (1984). On the relationship between task performance and associated verbalizable knowledge. *Quarterly Journal of Experimental Psychology,* **36A**, 209-291.

- *Study 2.* Maximize bus riders by changing spacing between buses and parking fees; achieve a target social response by changing social behavior; determine optimal level of taxation conditional on level of employment and inflation.

  Broadbent, D. E., Fitzgerald, P., & Broadbent, M. H. P. (1986) Implicity and explicit knowledge in the control of complex systems. *British Journal of Psychology*, **77**, 33-50.

Decision *Aids* May Be the Answer

"The unassisted hand and the understanding left to itself possess but little power. Effects are produced by the means of instruments and helps, which the understanding requires no less than the hand…."

Sir Francis Bacon

Novum Organum, 1620,

First Book, Aphorism 2

An Overview of Three Decision Aids

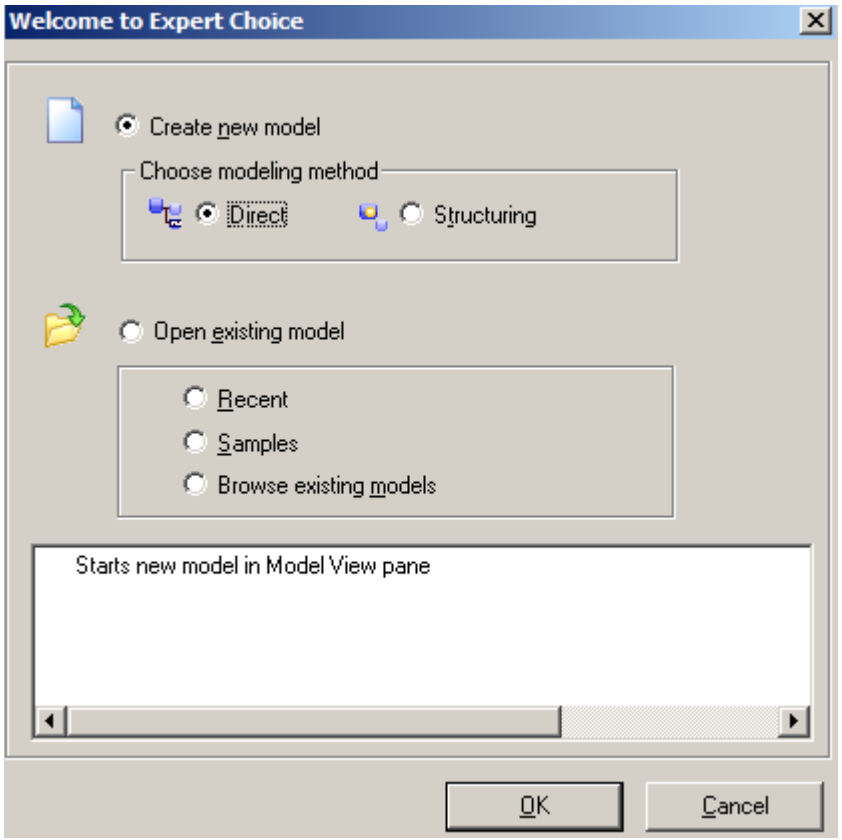
- Expert Choice (sound)
- Let Simon Decide (appealing)
- Wise Decider (sound & appealing)

Expert Choice's Opening Screen

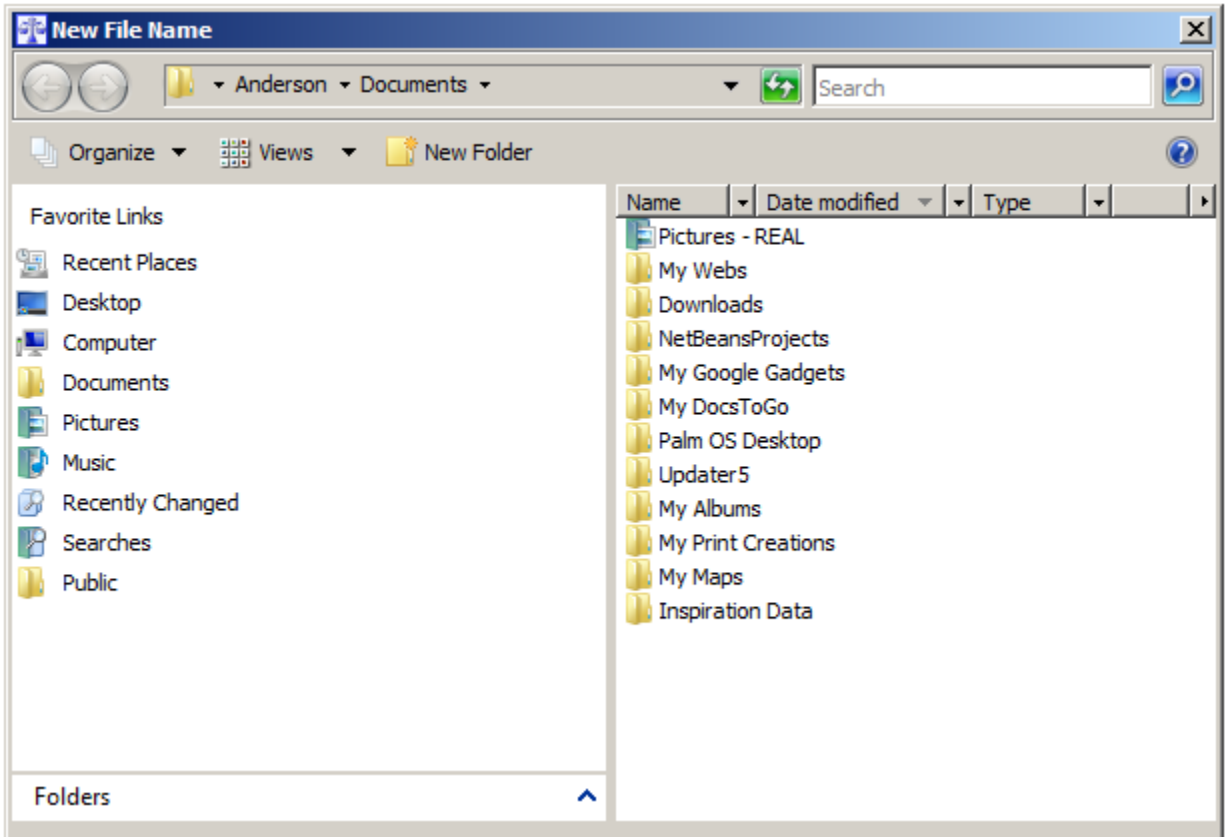
Let Simon Decide's Opening Screen

Wise D's Opening Screen

EC's First Page

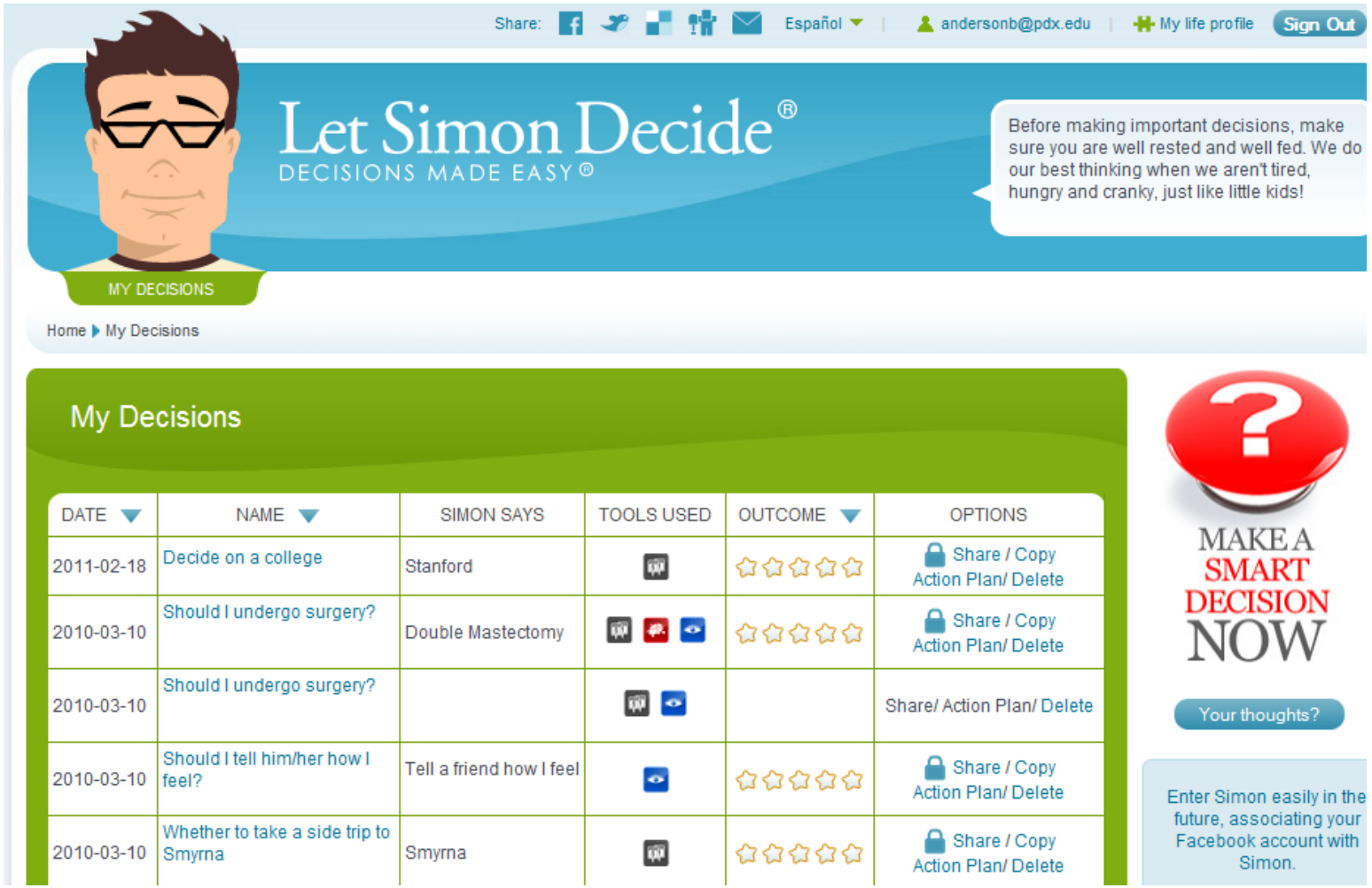


EC's Second Page

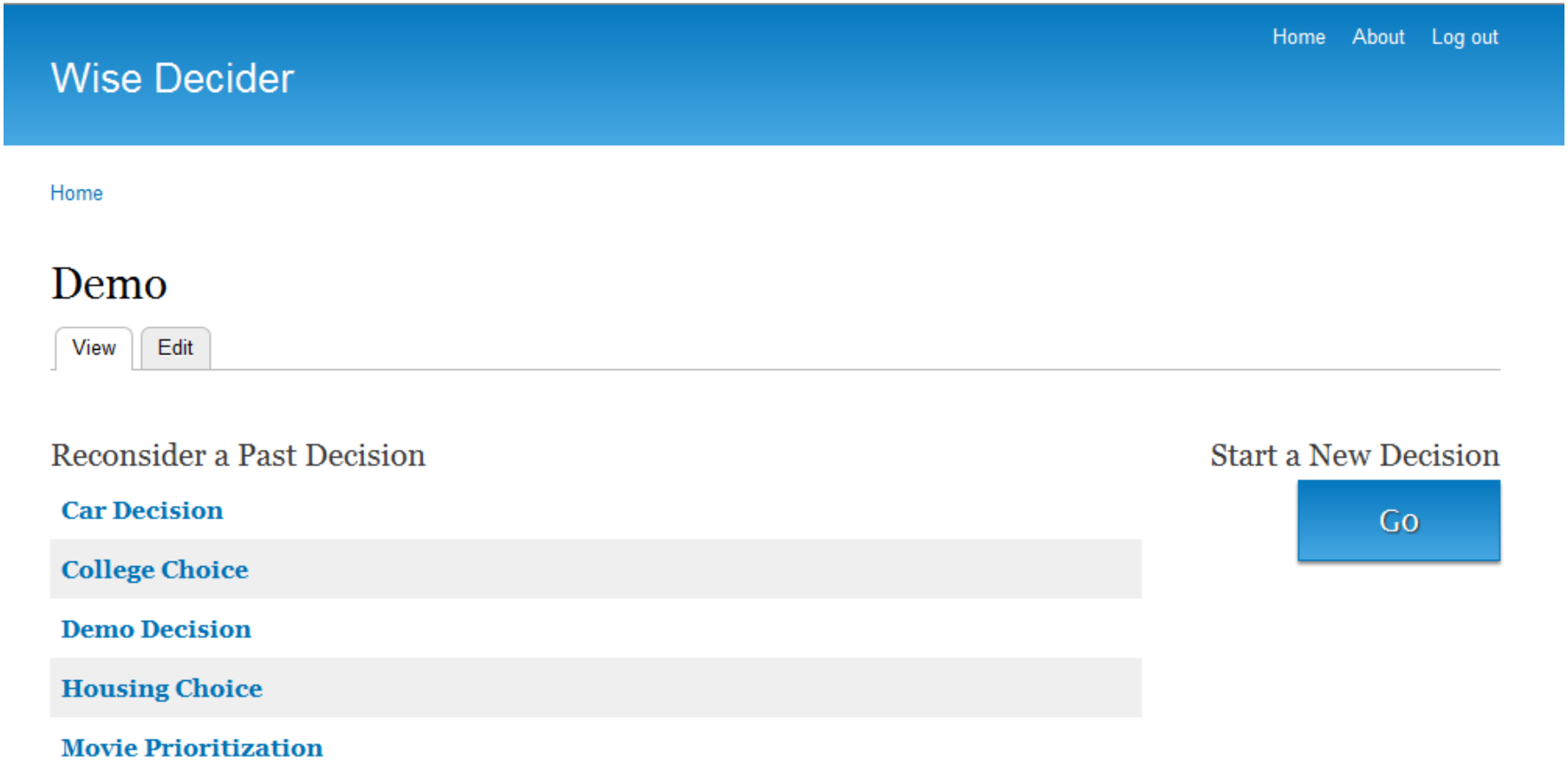


LSD's First Page

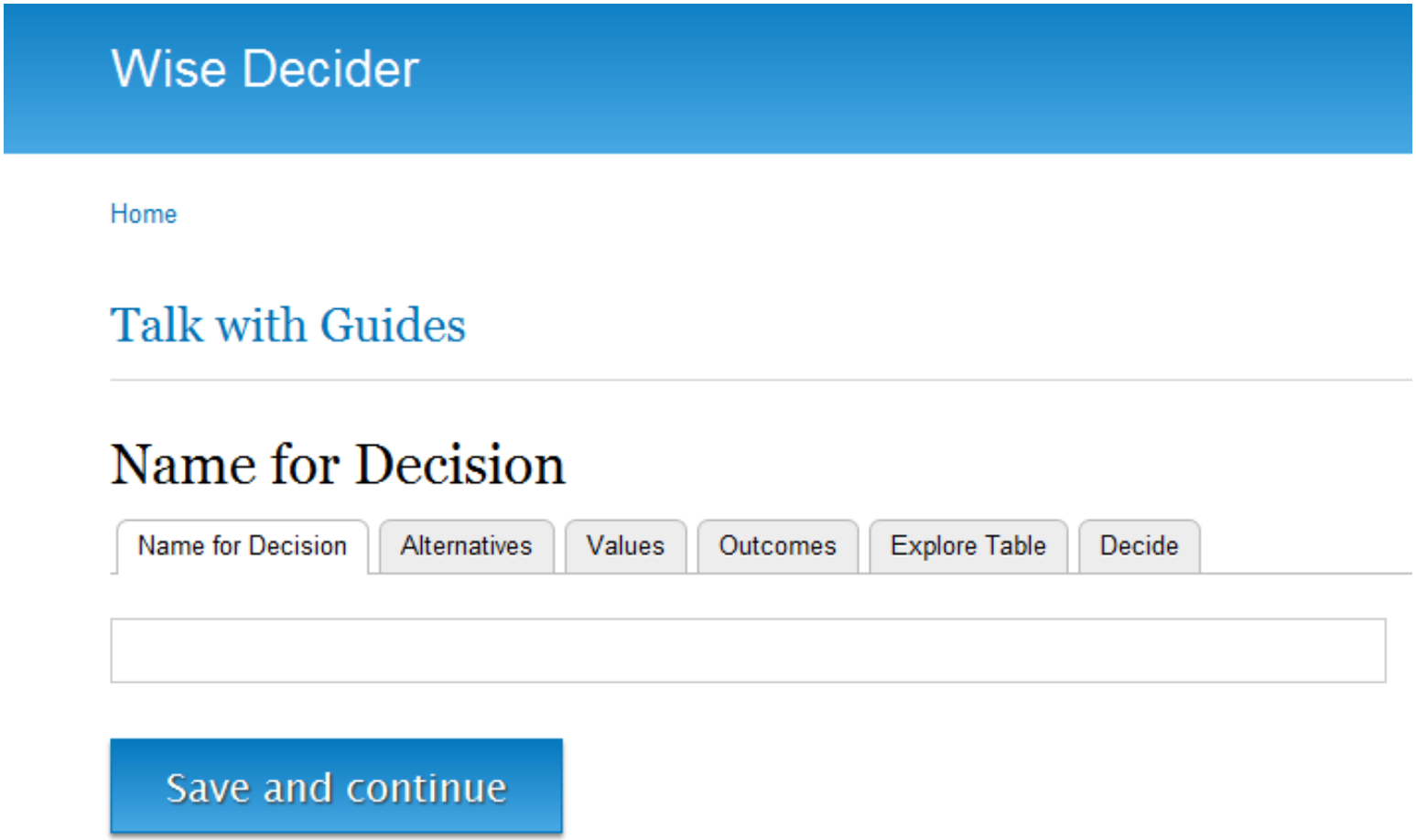
LSD's Second Page



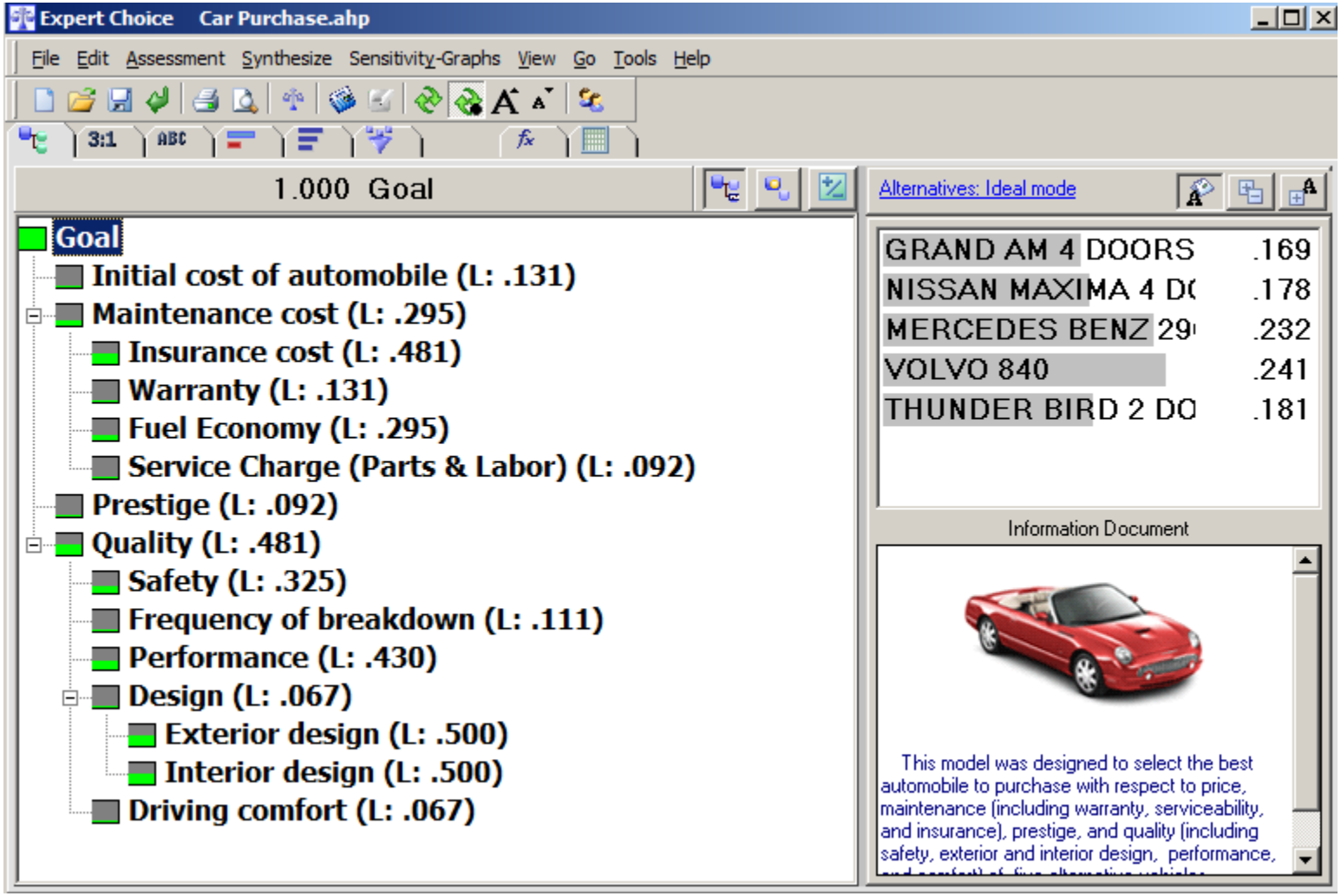
WD's First Page



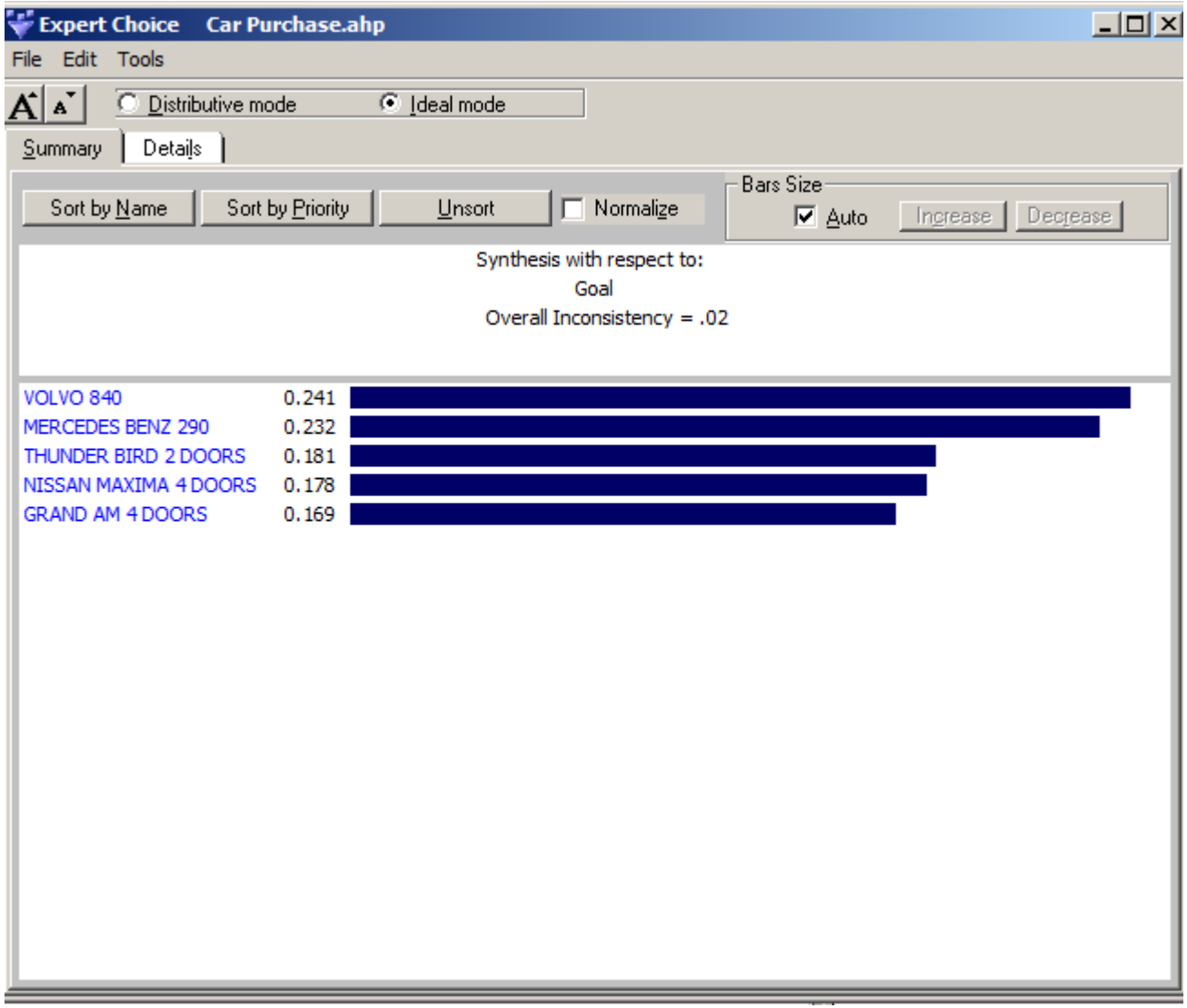
WD's Second Page



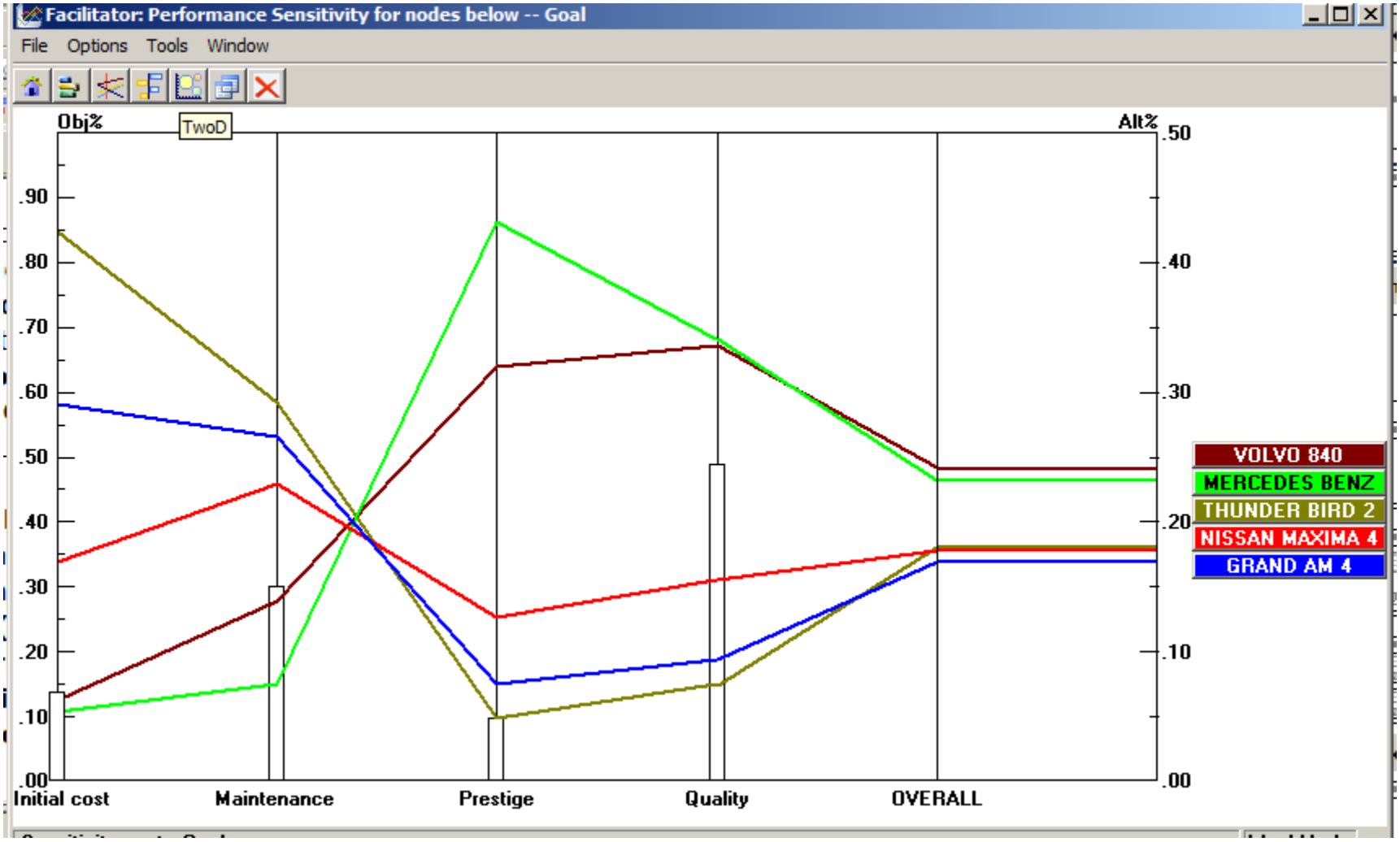
EC's Results I



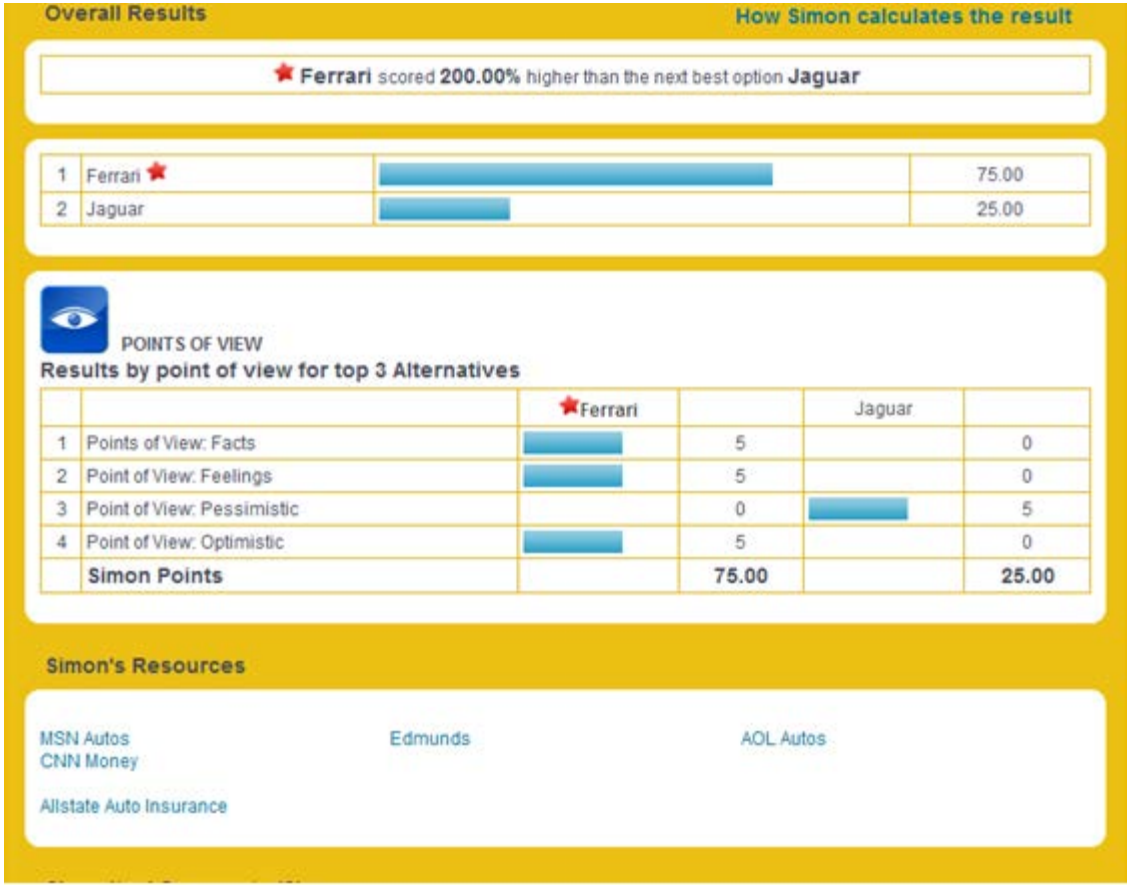
EC's Results II



EC's Results III



LSD's Results



Overall Results — How Simon calculates the result

Ferrari scored **200.00%** higher than the next best option **Jaguar**

1	Ferrari		75.00
2	Jaguar		25.00

POINTS OF VIEW

Results by point of view for top 3 Alternatives

		Ferrari		Jaguar	
1	Points of View: Facts		5		0
2	Point of View: Feelings		5		0
3	Point of View: Pessimistic		0		5
4	Point of View: Optimistic		5		0
	Simon Points		**75.00**		**25.00**

Simon's Resources

MSN Autos
CNN Money
Edmunds
AOL Autos
Allstate Auto Insurance

WD's Results

In the future:
Commensurated table colors

Talk with Guides

Explore Table

Name for Decision | Alternatives | Values | Outcomes | Explore Table | Decide

	Cost	Reliability	Crash Protection	Owner Satisfaction
Subaru Forester	$20-30,000	Intermediate	Best	Best
Honda CR-V	$22-30,000	Best	Next Best	Next Best
Acura MDX	$43,000-54000	Next Best	Best	Next Best

Notes

1. One-sentence justification
2. Uncertainties to monitor

A Closer Look at Wise Decider

Behavioral

- Forget *to* (S)

  Cup, spell checker, voice recognition

- Forget *how to* (R)

  Guides, embedded training

- Not motivated (+)

  Response counters, social reinforcement

Rational

- Decision Path
- Documentation

- Discussion, warning signs
- Externalization
- Observer perspective
- Process orientation
- Testability
- Publicity test
- Completeness & dominance tests

Intuitive

- Advisors
- Intuitive start
- Colors & Moveable rows and columns
- Instructions in external memory
- Instructions in small steps
- Completeness & dominance checks
- [Hidden math model]
- Intuitive check & justification

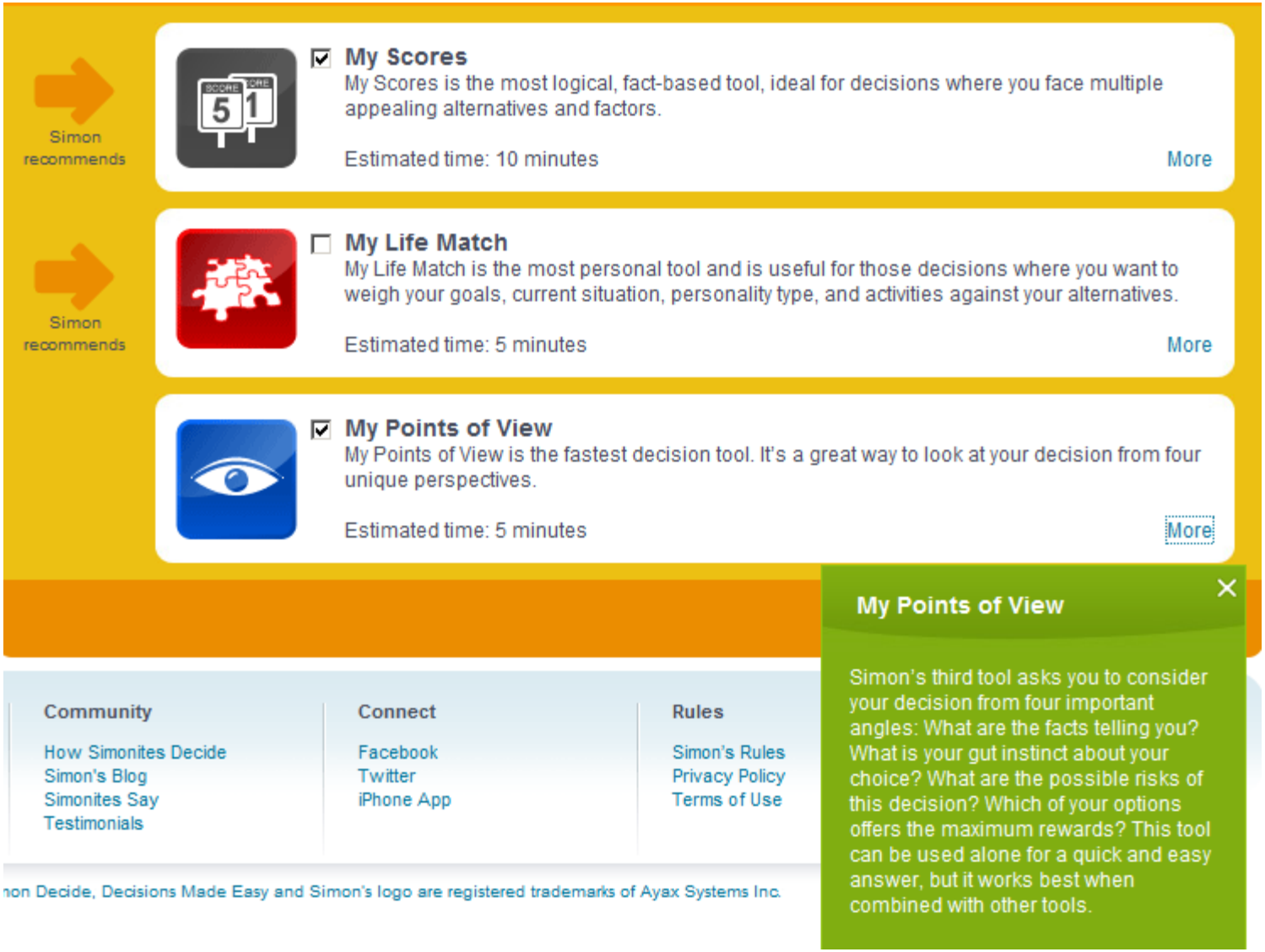
Three Approaches to Uncertainty

- Expert Choice
- Let Simon Decide
- Wise Decider

Expert Choice's Treatment of Uncertainty

AID	Alternatives	Benefits	Risks	Probability of Success	Expected Benefits
A1	Dairy Chart Recorder	.337	.4	0.6	0.202
A2	Dairy Structure Work	.406	.6	0.4	0.162
A3	Dairy Maintenance Work	.349	.5	0.5	0.175
A4	Solar Greenhouse	.346	0	1	0.346
A5	Cultivating Tractor	.417	0	1	0.417
A6	Crating System	.443	0	1	0.443
A7	New Pipeline Washer	.288	0	1	0.288
A8	Vacuum Milking System	.305	0	1	0.305
A9	Hot water heater	.449	0	1	0.449
A10	Whey tank	.478	0	1	0.478
A11	Barn electricity	.291	0	1	0.291
A12	Bulk tank fridge	.277	0	1	0.277

Let Simon Decide's Treatment of Uncertainty



Point of View: Pessimistic

BACK | SAVE | NEXT

Select what you think is the best alternative(s) for each of the following questions. Don't over think your answers--just pick whatever comes to mind.

If everything goes wrong, which alternative is your best option or the least risky?

- [ ] Start Own Business
- [ ] Start Partnership
- [x] Work For Someone Else

BACK | SAVE | NEXT

Overall Results

How Simon calculates the result

Work For Someone Else scored **0.00%** higher than the next best option **Start Own Business**

1	Work For Someone Else		50.00
2	Start Own Business		50.00
3	Start Partnership		0.00

POINTS OF VIEW

Results by point of view for top 3 Alternatives

		Work For Someone Else		Start Own Business		Start Partnership	
1	Points of View: Facts		5		0		0
2	Point of View: Feelings		0		5		0
3	Point of View: Pessimistic		5		0		0
4	Point of View: Optimistic		0		5		0
	Simon Points		**50.00**		**50.00**		**0.00**

WD's Treatment of Uncertainty

The following concepts are important to keep in mind as you enter the facts and values into your decision table:

- Testability
- Identifying uncertainty
- Using ranges and judging probabilities
- Column colors vs. table colors
- Coloring ranges

Here are five ways to modify an alternative, so that it will be less affected by uncertainty. If you're able in any of these ways to think of a more uncertainty-proof alternative, add it to your table, and see how it compares with your other alternatives.

- Control
- Get information
- Wait for information
- Diversify
- Share risk

Identifying & Representing Uncertainty I

- **Identifying uncertainty**. Which alternative is the riskiest? Which estimates of impact are the least certain? If this decision turns out badly, what's the most likely reason it will have turned out badly?

Identifying & Representing Uncertainty IIa

- For any cell where there is significant uncertainty, enter a range of values rather than a single value. For example, instead of entering a salary of $50,000 when you aren't at all certain that that will be the salary, you might enter the range $40,000-$60,000. Make the range broad enough that you feel there's a 99% chance that the actual value will turn out to be between the high and low ends of your range. A common human failing is to be overconfident in making predictions and to set ranges of uncertainty that are too narrow.
- For any cell where there is significant uncertainty, enter a range of values rather than a single value. For example, instead of entering a salary of $50,000 when you aren't at all certain that that will be the salary, you might enter the range $40,000-$60,000. Make the range broad enough that you feel there's a 99% chance that the actual value will turn out to be between the high and low ends of your range.
- We’re really not very good at judging probabilities. For one thing, we tend to think the future will be much like the past and, as a consequence, often encounter surprises that we haven’t adequately prepared for. For example, when we judge a 99% confidence interval, only 1% of the cases should fall outside that interval; instead the figure can approach 50% (Alpert & Raiffa, 1982). That’s a lot of surprises! This is why Wise Decider emphasizes uncertainty proofing, which doesn’t require thinking about probabilities. When you do have to think about probabilities, however, the following guidelines can improve your judgments.

Identifying & Representing Uncertainty IIb

- **Testability.** Start with a testable, preferably quantitative, description of the outcome, *e.g.,* "inches of rainfall in a 24-hour period", rather than just "rain" (Spetzler & von Holstein, 1975).
- **Statistics.** Start with objective statistics, when possible. For example, when thinking about how long a marriage might survive, start with statistics for the general population. We tend to have more confidence than we should in vivid examples about what we know about the particular case (here, the particular couple) than in abstract statistics (Kahneman & Tversky, 1979), but we should resist this tendency, since the statistics are based on more cases and are more reliable.
- **Adjustment.** You can then adjust these statistics to take into account what you know about the case at hand, but keep in mind that what you know about any particular case is rarely all that informative and rarely justifies much adjustment. To correct the tendency to set ranges of uncertainty that are too narrow, push the upper and lower limits out to where they feel uncomfortable. If you're judging a 99% confidence interval for how long a marriage will last, the low end of the range should usually be so low that you feel uncomfortable about it, and the high end of the range should usually be so high that you feel uncomfortable about. It can help to try to think of specific causes or scenarios that might result in an extremely high value and specific causes or scenarios that might result in an extremely low value. (Fischhoff, 1982).
- **Frequencies.** We think better in terms of frequencies, rather than percentages or probabilities (Gigerenzer, 1991). Imagine that you have an urn with 99 white balls and 1 black ball, and ask yourself, Is it more likely that the event (*e.g.,* the marriage ends after 6 months) will occur or that you'd draw a black ball from this urn? If it's more likely that the event will occur, Is it more likely that you'd draw a black ball from an urn with 50 white balls and 50 black balls? On the other hand, if it's more likely that you'd draw a black ball from the original urn with 99 white balls and 1 black ball, change the question to, Is it more likely that you'd draw a black ball from an urn with 999 white balls and 1 black balls. By asjusting up and down in this way, you should be able to arrive at an urn where you're unable to say whether it's more likely that you'd draw a black ball from that urn or that the event would occur.
- **The availability trap.** We tend to judge events that are more available to memory as more probable (Kahneman & Tversky, 1979). Certainly, events that occur often are easier to remember, but so also are events that have occurred recently or are vivid. People tend to be reluctant to fly shortly after an airlines hijacking, even though the probability of a hijacking may actually be reduced for a time while people are more alert. When you're judging a probability, consider whether recent and/or vivid events might be biasing your judgment.

Identifying & Representing Uncertainty III

- **Coloring ranges**. The color appropriate for an uncertain cell will, of course, be between that for the best end of the range and that for the worst end of the range. Specifically, (a) *if you're risk neutral,* the color for an uncertain cell will be the color appropriate for the long-run average value that would be expected if the decision were to be repeated many times; OR (b) *if you're risk averse,* as most people usually are, the color for the cell will be a lower (darker) color than that. *If, in the unlikely case that you're risk prone*, the color for the cell will be a higher (lighter) color.

“Uncertainty Proofing”

- Control
- Get information
- Wait for information
- Diversify
- Share risk

Adding Mathematics to Wise Decider

- Problem structuring: Identification of redundancy & irrelevance
- Choice: Identification of dominance
- Conflict resolution: Identification of winning trades
- Uncertainty: Sensitivity analysis to guide uncertainty proofing
- [Probability trees? (a) Identify positively correlated uncertainties and mediating event, (b) split row, (b) request probabilities?]
- Justification: Identification of sufficient reasons