

# Introduction to Multi-Criteria Decision Analysis

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# Introducing myself

- Alex Zabeo



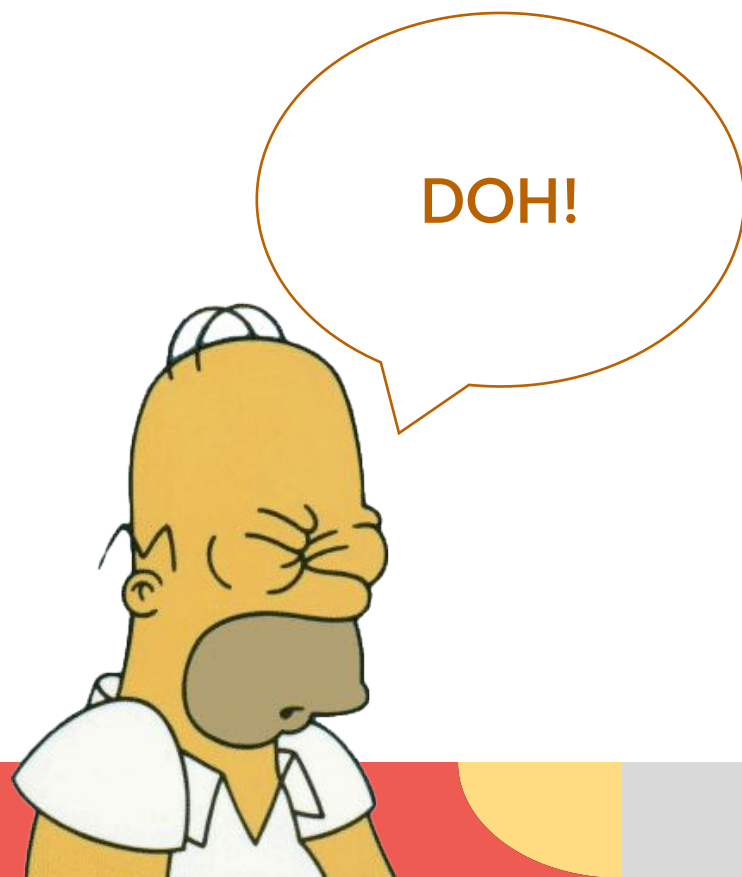
- Senior Researcher, Ph.D. in Computer Science.  
His research activities focus on decision analysis, probabilistic risk assessment and life cycle assessment (LCA).  
He has a proven experience in the design and development of standard and geographic decision support systems (DSS) and in Multi-Criteria Decision Analysis (MCDA) - Fuzzy Logic (FL) - Value of Information (Vol) - artificial intelligence (AI) based evaluation methodologies as well as in the design and implementation of studies and software related to Life Cycle Assessment (LCA) and the management of complex sensor networks and Internet of Things (IoT).  
He led the Decision Support area of several European and national projects.  
He is a founding partner and CTO of GreenDecision Srl [www.greendecision.eu](http://www.greendecision.eu)

# Why decision analysis?

# Why decision analysis?



# Why decision analysis?



# Why decision analysis?

- “Humans are quite bad at making complex, unaided decisions” (Slovic et al., 1977).
- Individuals respond to complex challenges by using **intuition** and/or personal **experience**



**TED**  
Ideas worth spreading

- [http://www.ted.com/talks/dan\\_gilbert\\_researches\\_happiness](http://www.ted.com/talks/dan_gilbert_researches_happiness)



# Why decision analysis?

- Would you pay 25€ for a coke?



No way!



# Why decision analysis?

- Would you pay 25€ for a ~~coke~~ beer?





# Why decision analysis?

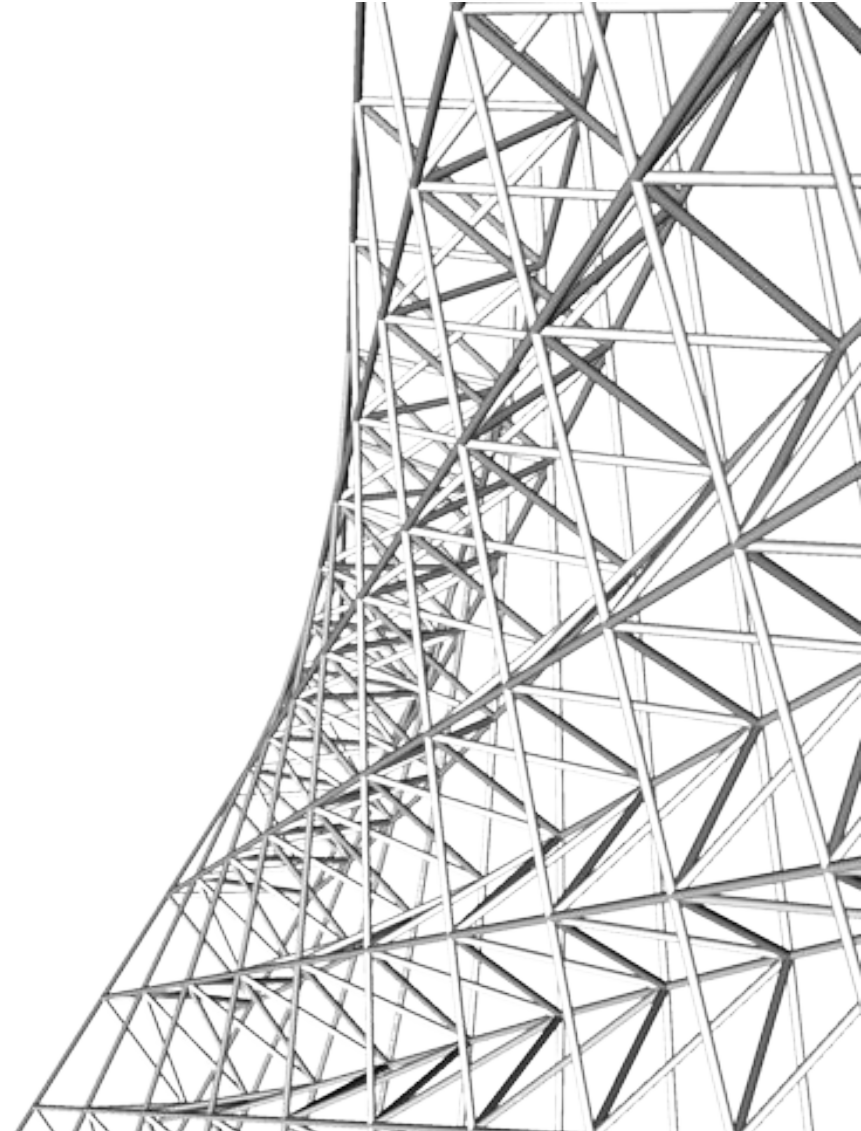
- Would you pay 25€ for a coke beer?



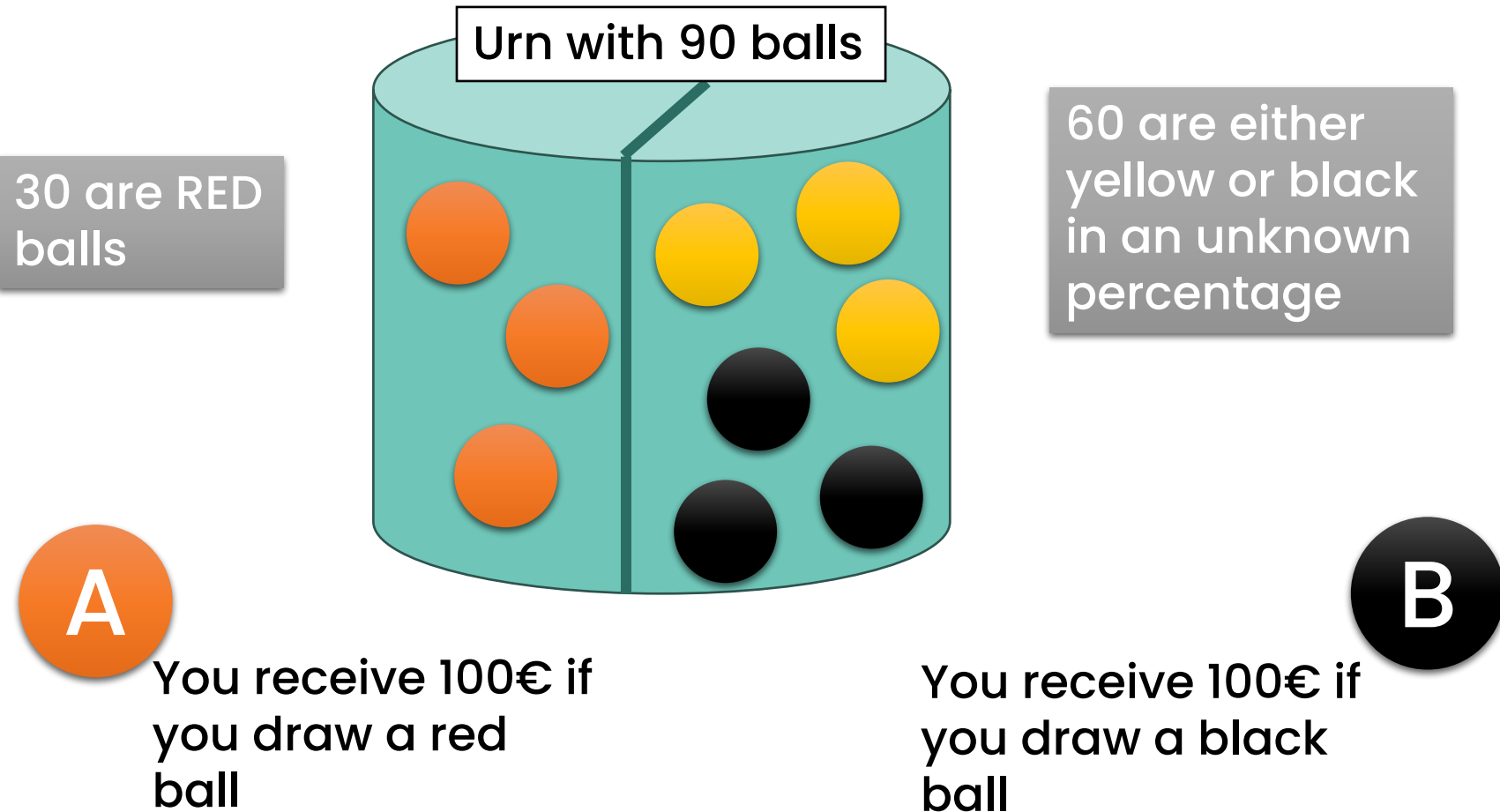
# Structured decision

# Structured decision

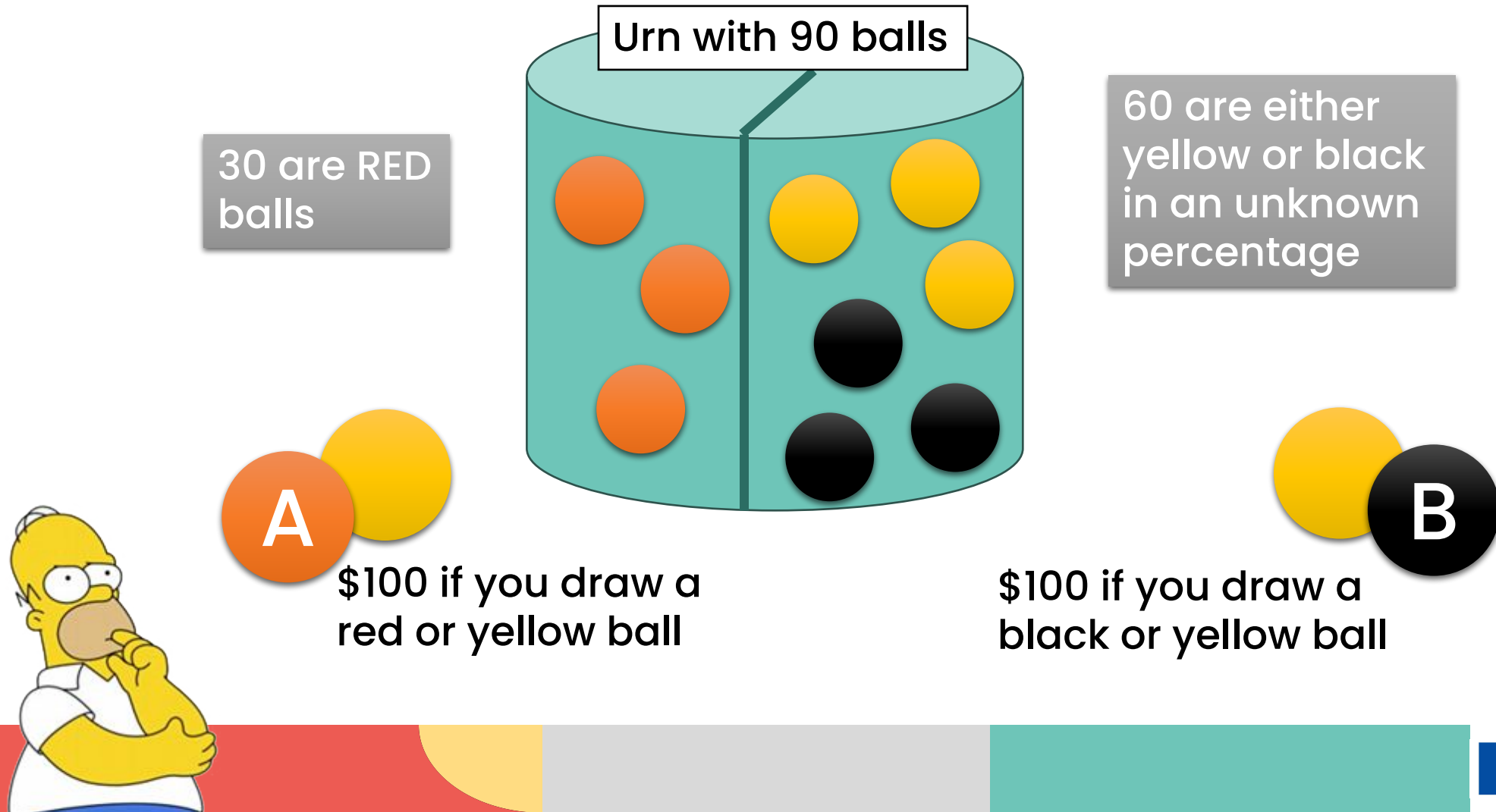
- Improves objectiveness
- Decreases uncertainty
- Allows repeatability
- Fosters transparency
- Simplifies group decisions
- Force coherence



# About coherence – Bet 1



# About coherence – Bet 2

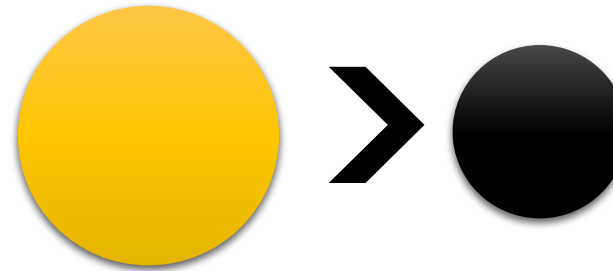
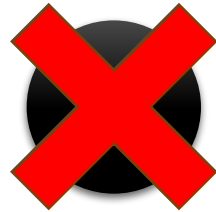




# Ellsberg paradox

You believe there are more yellow than black balls

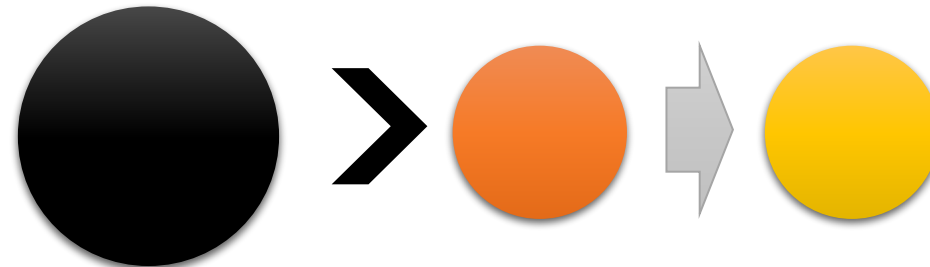
BET 1



You believe there are more black than red balls

Therefore more black than yellow!

BET 2





# How to structure decision?

# How to structure decision?

- Understand the problem
- Select alternatives
- Select criteria
- Quantify criteria
- Define the Decision Maker
- Elicit preferences
- Model the process
- Take the decision



# Understand the problem



How to  
get rid of  
it?



# Understand the problem



The screenshot shows the Wikipedia article for 'Hornet'. The page layout includes the Wikipedia logo and navigation links on the left, the article title and summary at the top, and a detailed description of hornets in the main content area. A small image of an Oriental hornet is also visible.

**WIKIPEDIA**  
The Free Encyclopedia

Main page  
Contents  
Featured content  
Current events  
Random article  
Donate to Wikipedia  
Wikimedia Shop

Interaction  
Help  
About Wikipedia  
Community portal  
Recent changes  
Contact page

Tools  
What links here  
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## Hornet

From Wikipedia, the free encyclopedia

*This article is about all true hornets. For other uses, see Hornet (disambiguation).*

**Hornets** are insects that are the largest eusocial wasps. Some species can reach up to 5.5 cm (2.2 in) in length. The true hornets make up the genus **Vespa** and are distinguished from other vespines by the width of the vertex (part of the head behind the eyes), which is proportionally larger in *Vespa* and by the anteriorly rounded gasters (the section of the abdomen behind the wasp waist). The best known species is the European hornet (*Vespa crabro*), about 2–3.5 cm in length, widely distributed

**Hornet**

Oriental hornet, *Vespa orientalis*

**Scientific classification**

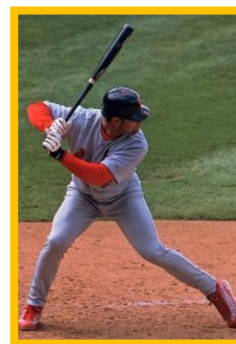
Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Hymenoptera



# Select alternatives



Tear down the wall



Smash the hive



Set the hive on fire



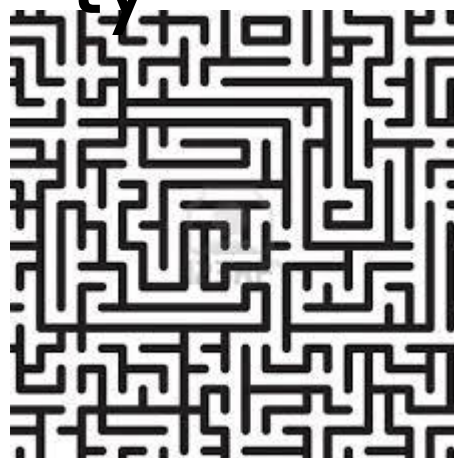
Smoke the hornets and remove the hive

# Select criteria



Time

Feasibility



Cost



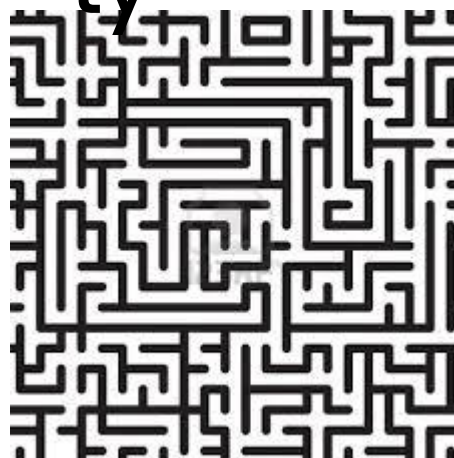
# Quantify criteria



Time  
Hours  
s

Indicators ?

Feasibility



Costs  
Euro  
s

# Define the decision maker

Single  
DM

Let's tear  
down the  
whole  
wall!



Group  
DM

I don't  
think so.



# Elicit preferences

Fast and  
funny  
regardless  
of cost!

Cheap  
and safe.



# Model the decision process

$$\begin{aligned}2 \sum_{j=1}^n (n-j)(j-1) &= 2 \sum_{j=1}^n (nj - j^2 - n + j) \approx \\&\approx 2 \sum_{j=1}^n nj - 2 \sum_{j=1}^n j^2 = 2n \sum_{j=1}^n j - 2 \sum_{j=1}^n j^2 = \\&= 2n \frac{n(n+1)}{2} - 2 \left( \frac{n^3}{3} + \frac{n^2}{2} + \frac{n}{6} \right) \approx \\&\approx n^3 - \frac{2n^3}{3} = \frac{n^3}{3} \\2 \sum_{j=1}^n (n-j)(j-1) &\approx \frac{n^3}{3}\end{aligned}$$



# Take the decision

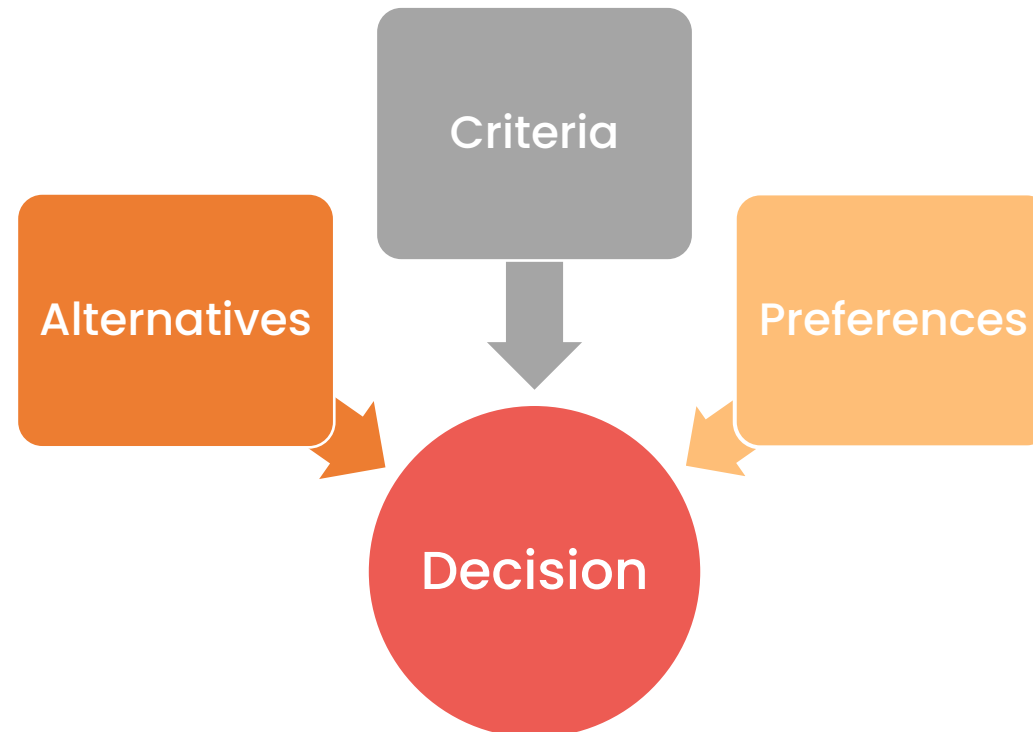


# Multi Criteria Decision Analysis (MCDA)



# Multiple Criteria Decision Analysis

- Methodologies to aid decisions when multiple criteria are involved



# Multiple Criteria Decision Analysis

- Given a set A, made by n alternatives and
  - a set G, of m evaluation criteria/attributes.
  - Build Evaluation/Impact matrix E (n x m)
    - Element  $e_{i,j}$  represent evaluation of the  $i^{\text{th}}$  alternative by means of the  $j^{\text{th}}$  criterion.
    - The evaluation matrix may include quantitative, qualitative or both types of information.
- From the set of DM preferences P and Evaluation matrix E
  - Evaluate the requested decision problem

Different between  
methods

# Evaluation/Impact matrix

Buy a car  
example

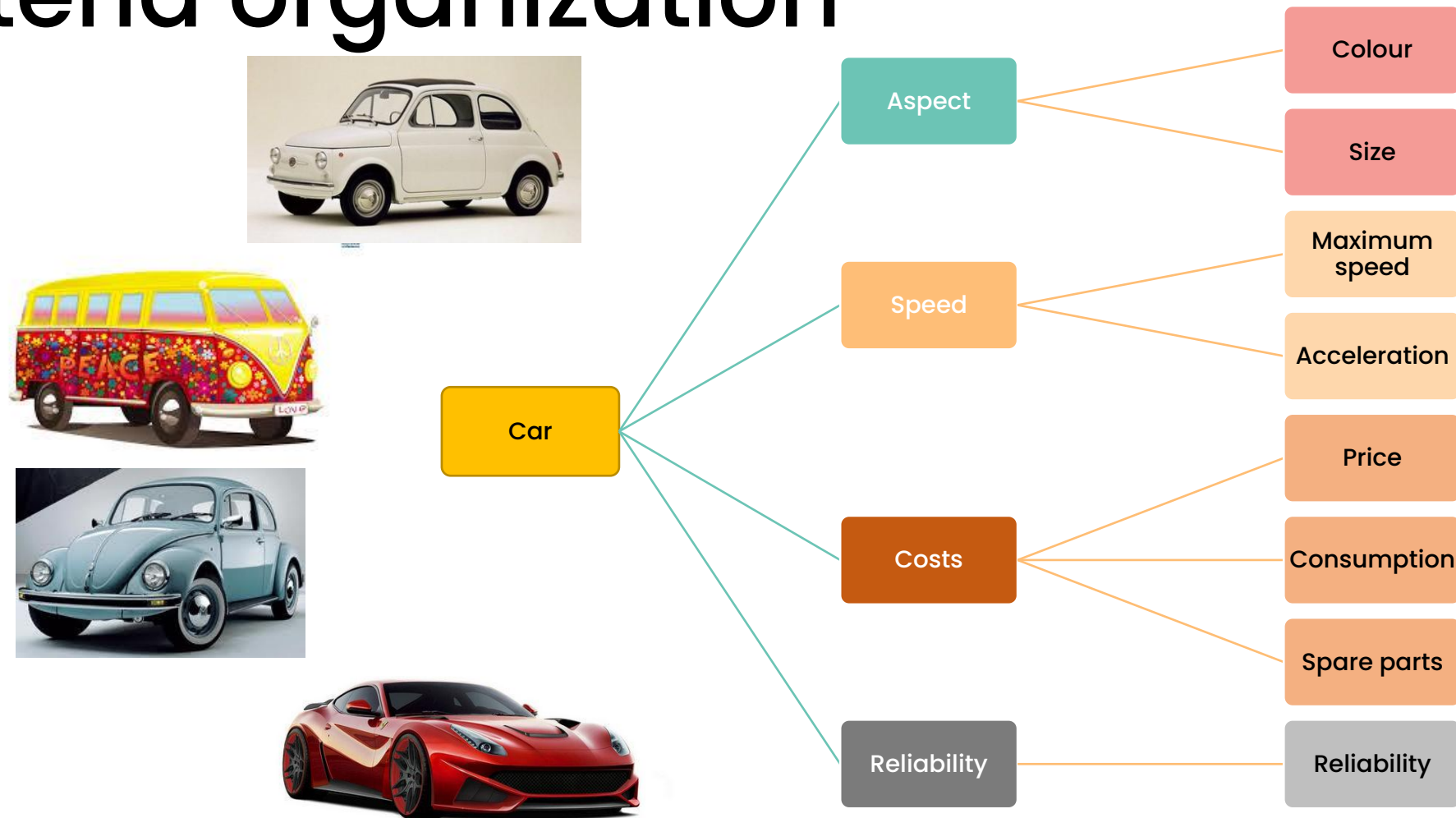


	Colour	Size	Maximum speed	Acceleration	Price	Consumption	Spare parts	Reliability
<b>Fiat 500</b>	white	small	80 km/h	-	5k€	16 km/lt	cheap	low
<b>Beetle</b>	blue	medium	130 km/h	50 sec	8k€	15 km/lt	cheap	medium
<b>Minivan</b>	yellow	big	100 km/h	120 sec	20k€	13 km/lt	cheap	medium
<b>Ferrari</b>	red	medium	280 km/h	6 sec	200k€	2 km/lt	expensive	high

# Alternatives & criteria

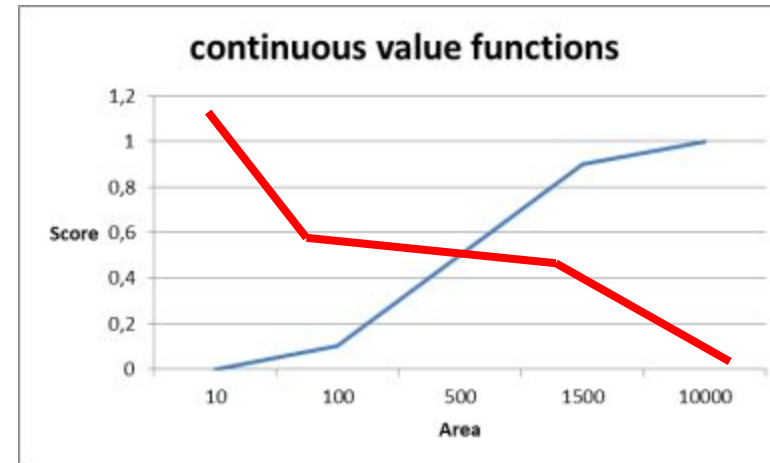
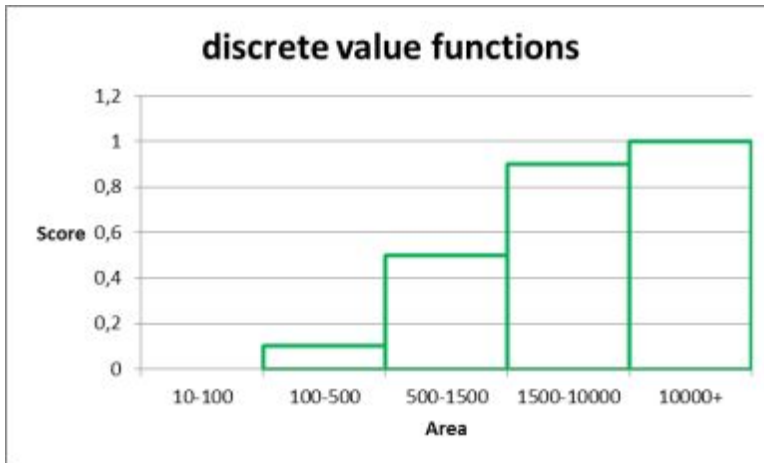
- Alternatives are just **labelled criteria configurations**
- **Criteria selection, quantification and normalization** are crucial steps
- **Aggregation of criteria in the light of DM preferences** concerns MCDA methodologies

# Criteria organization



# Multi Attribute Value Theory

- Value functions – normalization / classification

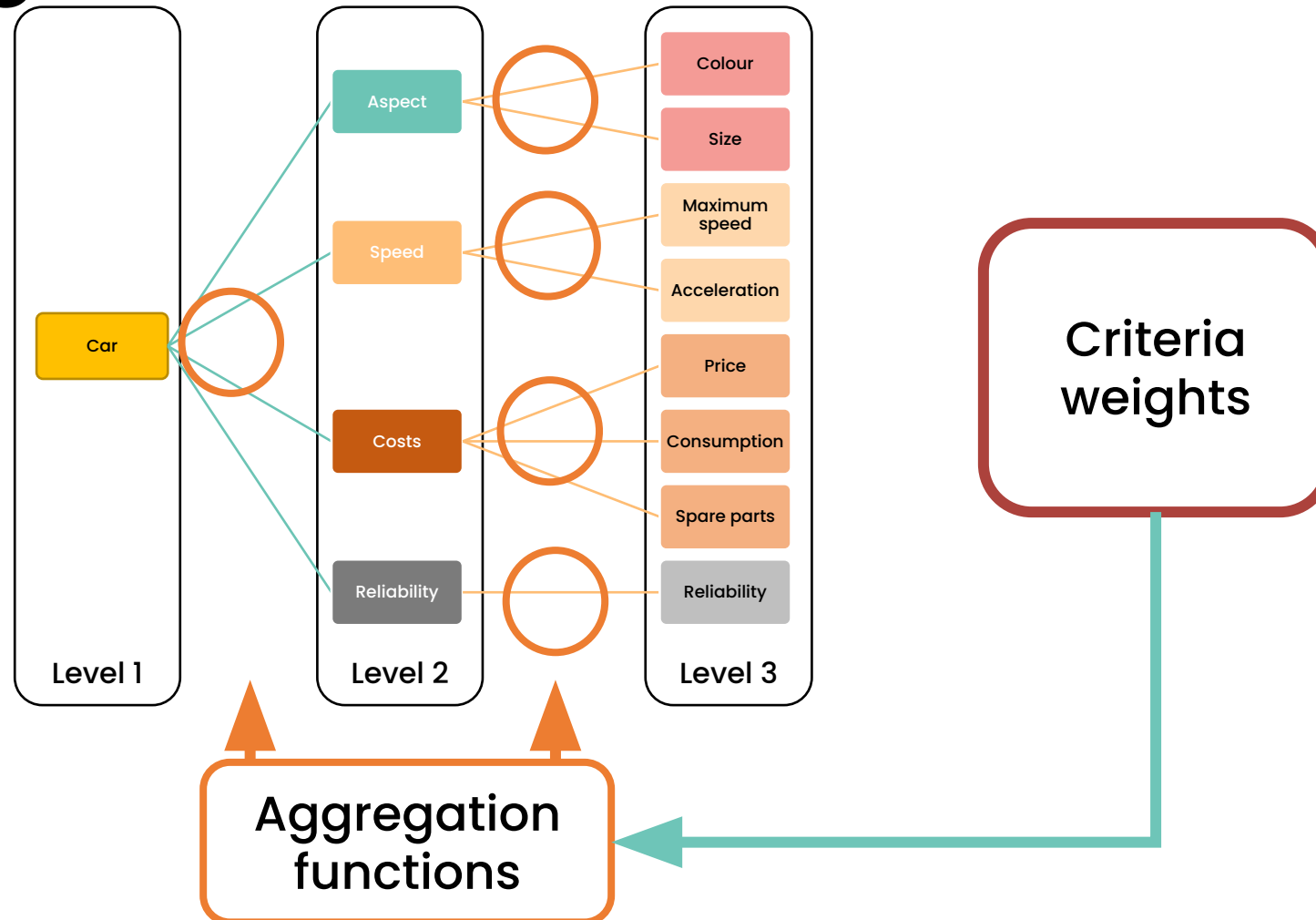


*Todo necio confunde valor y precio*  
Antonio Machado





# Aggregation methods



# An example

Normalization

	Color	Speed	Consumptions
Citroen	red	180	18
Fiat	blue	120	20
Renault	green	150	21

	Color	Speed	Consumptions
Citroen	0,2	0,7	0,7
Fiat	0,4	0,5	0,9
Renault	0,8	0,6	1,0

Preferences

Weight	0,2	0,3	0,5
	Color	Speed	Consumptions
Citroen	0,2	0,7	0,7
Fiat	0,4	0,5	0,9
Renault	0,8	0,6	1,0

Weight	0,2	0,3	0,5		
	Color	Speed	Consumptions	Score	Rank
Citroen	0,2	0,7	0,7	0,60	3
Fiat	0,4	0,5	0,9	0,68	2
Renault	0,8	0,6	1,0	0,84	1

Aggregation

Can you spot the error?



# MCDA is only a tool not a DM!



Thank you for your  
attention!



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# scan to

**TAKE OUR SURVEY ON SAFETY AND SUSTAINABILITY TRADE-OFFS**

This survey aims to explore perceptions, decision-making processes, and factors affecting/influencing the potential safety and sustainability trade-offs.

SCAN ME

SCAN ME



SCAN ME

Do you have questions or want to participate in the follow-up oral interviews?

Contact us at [info@sunrise-horizon.eu](mailto:info@sunrise-horizon.eu).