Epistemological foundation: Modelling

Theory needs to be *verifiable*.
Means here: Models need to be *testable*.

Observations, reasoning, and experiments can be ***repeated*** and ***checked*** independently by other observers.

Modelling: Why?

What for?
Prediction and explanation

Examples for models:

- Street maps
- Mathematical equations for spread of an infection
- Gene expression network for the cell cycle
- Communication structure in a company

How good is a model?
Rephrase as: How good is it *at the task what you want it to do (prediction and/or explanation)?*

On models

"All models are wrong, some are useful."

George Box, FRS(1919-2013)
English statistician who worked on quality control, time series, design of experiment, response surfaces, Bayesian inference

Student of Pearson
Imperial Chemical Industries
Founder of Dept of Stats at Wisconsin-Madison
Director of Statistical Research Group at Princeton

On approximation

"An approximate answer to the right question is worth a great deal more than a precise answer to the wrong question."

John Wilder Tukey (1915 – 2000)
American chemist, mathematician and statistician
FFT algorithm, various statistical test, EDA

Modelling: Basic definitions

model *(n): a miniature representation of something; a pattern of something to be made; an example for imitation or emulation; a description or analogy used to help visualize something (e.g., an atom) that cannot be directly observed; a system of postulates, data and inferences presented as a mathematical description of an entity or state of affairs*

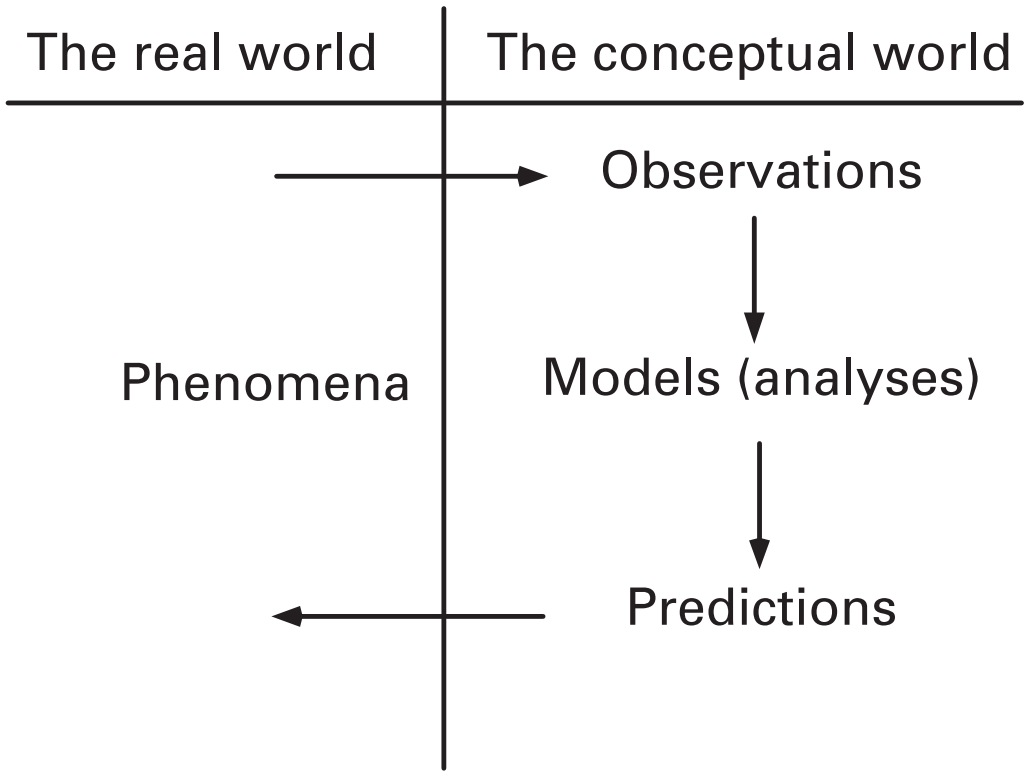


Figure 1.1 An elementary depiction of the *scientific method* that shows how our conceptual models of the world are related to observations made within that real world (Dym and Ivey, 1980).

http://www.sfu.ca/~vdabbagh/Chap1-modeling.pdf

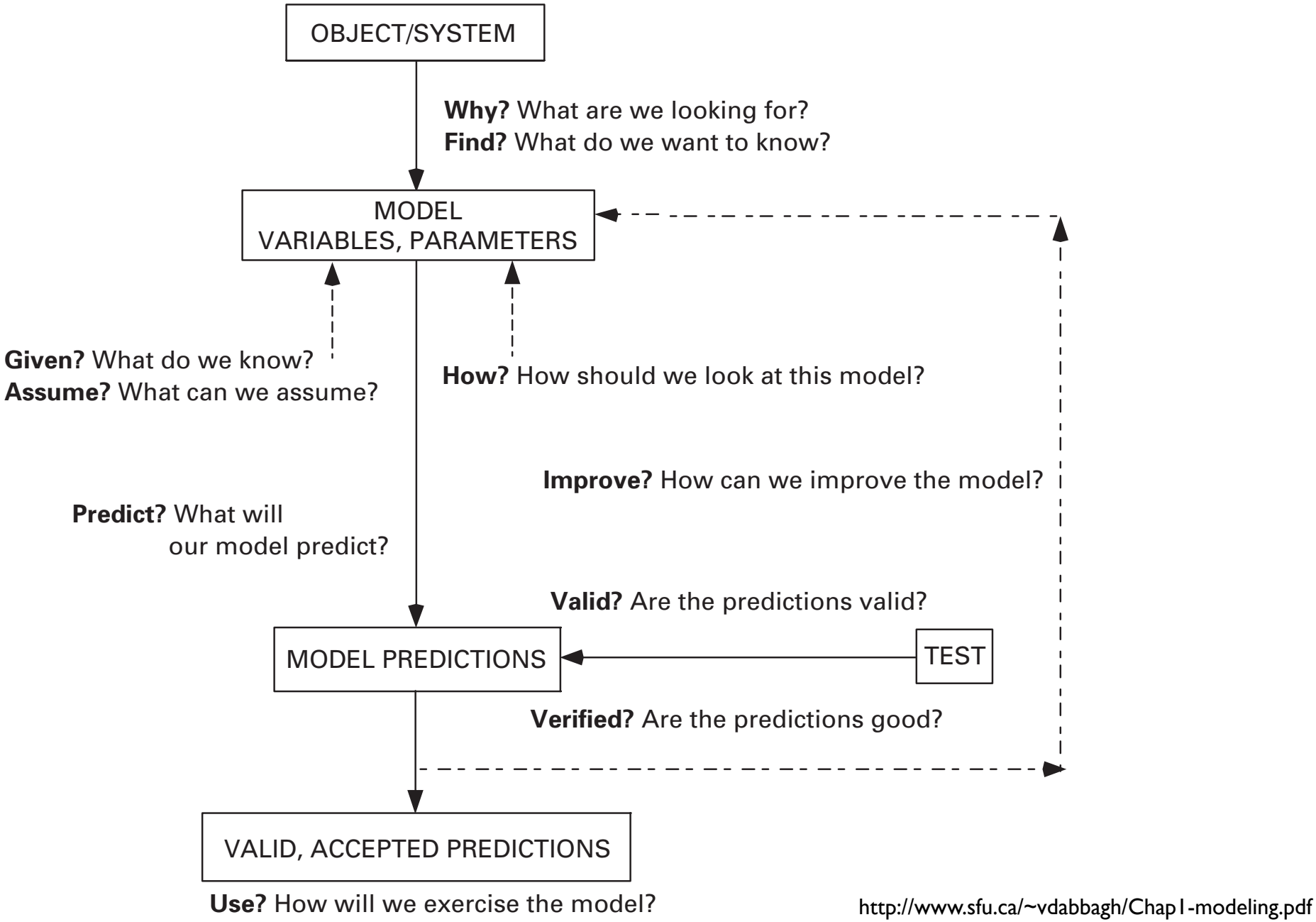
Modelling: Definition and use

model *(n): a miniature representation of something; a pattern of something to be made; an example for imitation or emulation; a description or analogy used to help visualize something (e.g., an atom) that cannot be directly observed; a system of postulates, data and inferences presented as a mathematical description of an entity or state of affairs*

mathematical model *(n): a representation in mathematical terms of the behavior of real devices and objects*

http://www.sfu.ca/~vdabbagh/Chap1-modeling.pdf

Modelling: How to build a model?



http://www.sfu.ca/~vdabbagh/Chap1-modeling.pdf

Empirical research basics: Types of observations

Field study:

- Can be purely observational or include intervention
- Many different study types are being used
- Subject to many biases by close to reality

Lab experiment:

- Experimental design (methodological area of in statistics) has many options to minimise bias
- Can control conditions
- Need to address concerns like realism, awareness of subjects of being in an experiment

What about simulations, data perturbations etc?

They are helpful additional tools in building and validating models, but they are *not* empirical evidence.

On model selection

"Make your theory as simple as possible, but no simpler."

Albert Einstein

"For every complex question there is a simple and wrong solution."

Albert Einstein

Definition: Normative theory

Normative theories of decision making:

- How people *should* behave when taking decisions
- Based on an idealised form of human being, specifically, *homo economics (*i.e. rational maximiser of self-interest)
- Inspired by economists' personal perceptions of real humans or on ideology
- Not based on systematic observation of human behaviour
- Methods: Mathematical axioms and optimisation
- Works well or satisfactory in many cases, fails in many others

http://epublications.uef.fi/pub/urn_isbn_978-952-458-985-7/urn_isbn_978-952-458-985-7.pdf

Example for a normative model: homo economicus

Species: *Homo economicus*

Another term for economic man.

Defintion:

Using rational assessments, homo economicus attempts to maximize utility as a consumer and economic profit as a producer

http://www.oxforddictionaries.com/definition/english/homo-economicus

Species: Homo Economicus

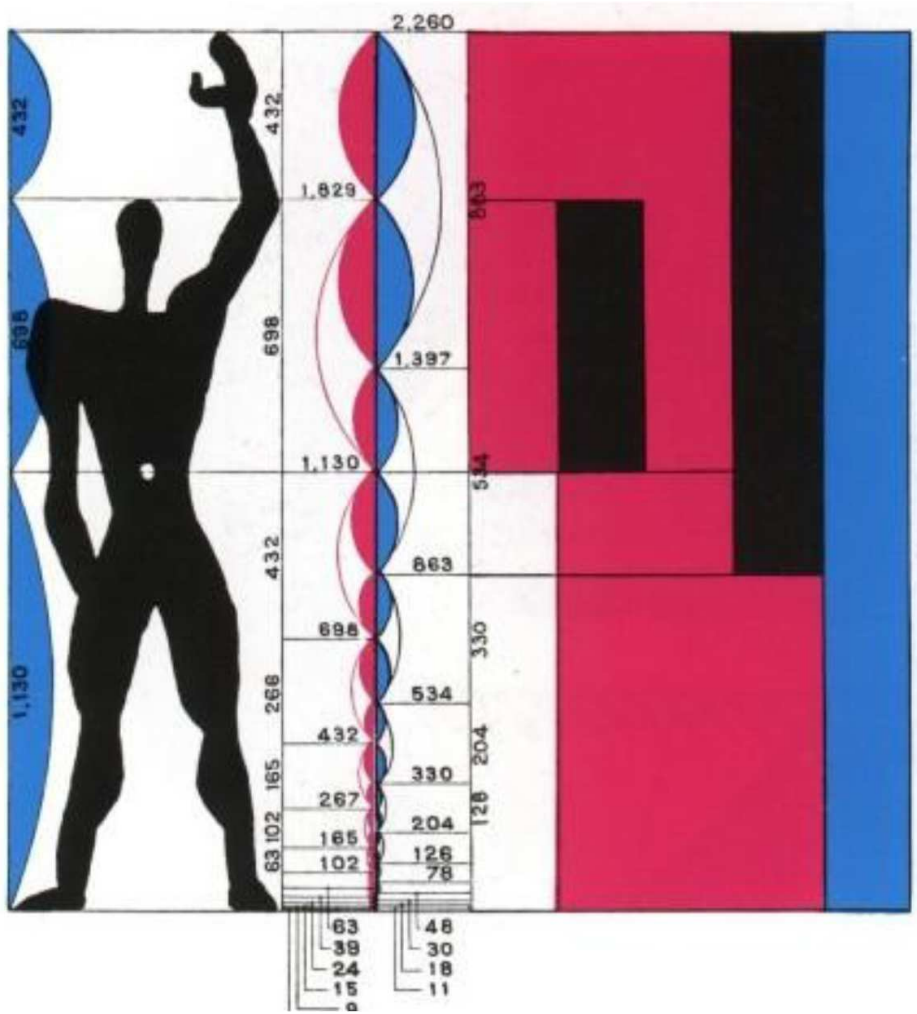
Rational in the sense of…

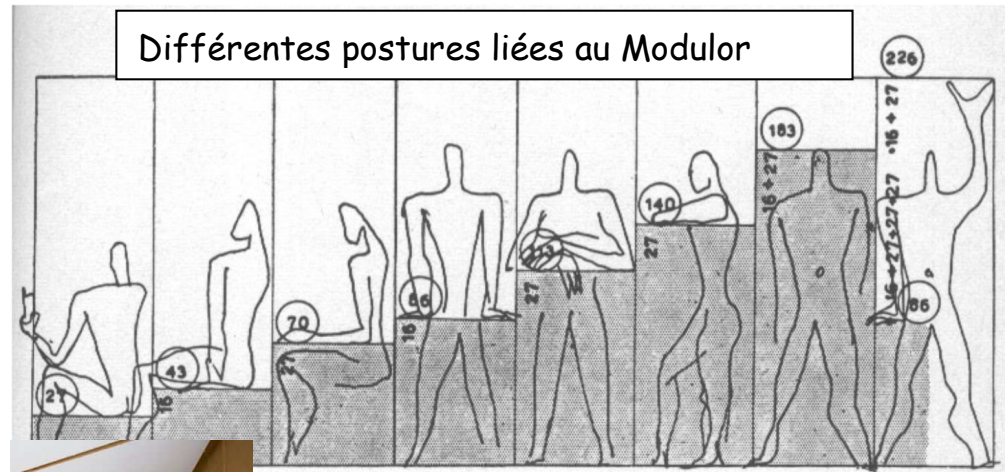
- Maximising some exogenous, stable set of preferences that depend on absolute levels of outcomes
- Ability to include uncertainty (EUT)
- Uses logic and axioms of probability to process information
- Ability to include dynamic situations (discounting)
- Ability to make and follow intertemporal plans (even contingent one) without conflict between preferences of current and future selves
- Has perfect will-power
- Perfectly self-interested

http://econweb.ucsd.edu/~v2crawford/142BehavioralDecisionIntroductionSlides08.pdf

Example for a normative model: L'homme moyen

L'homme moyen and *Le Modulor* by Le Corbusier (1887-1965)





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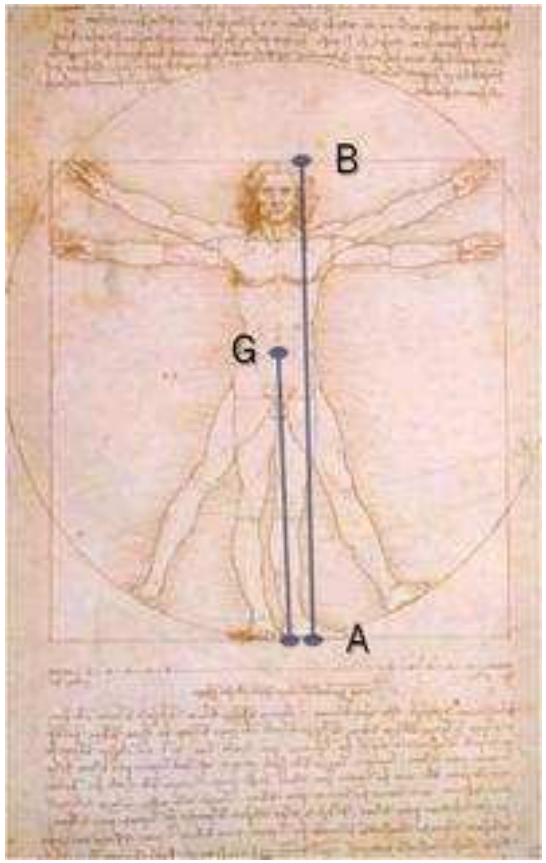
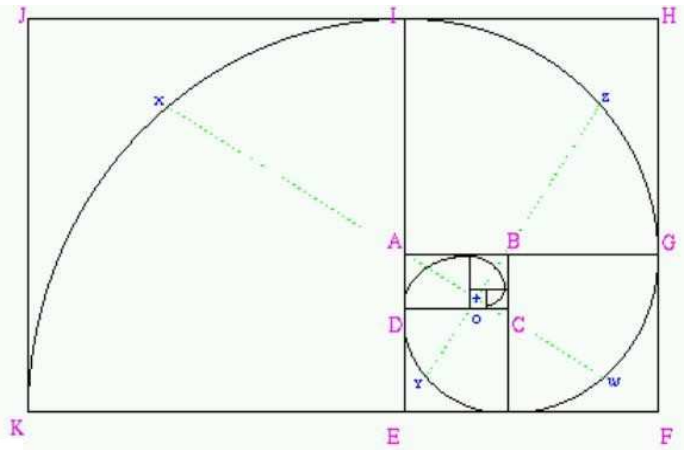
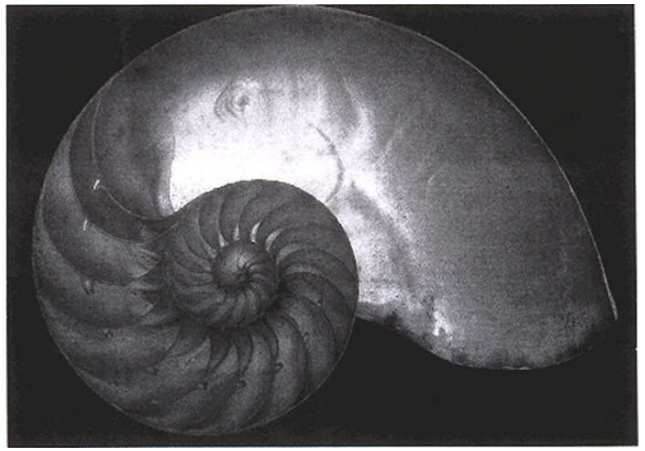


Le Corbusier's model for humans is largely based on *mathematical* principles: Golden ratio, Fibonacci numbers, and reminds of Leonardo da Vinci's *homme de vertruve*.



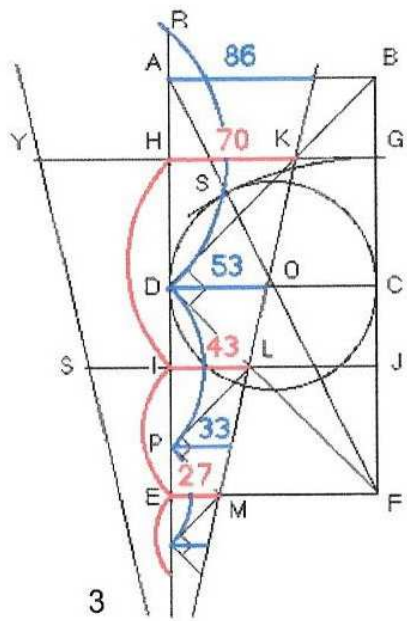


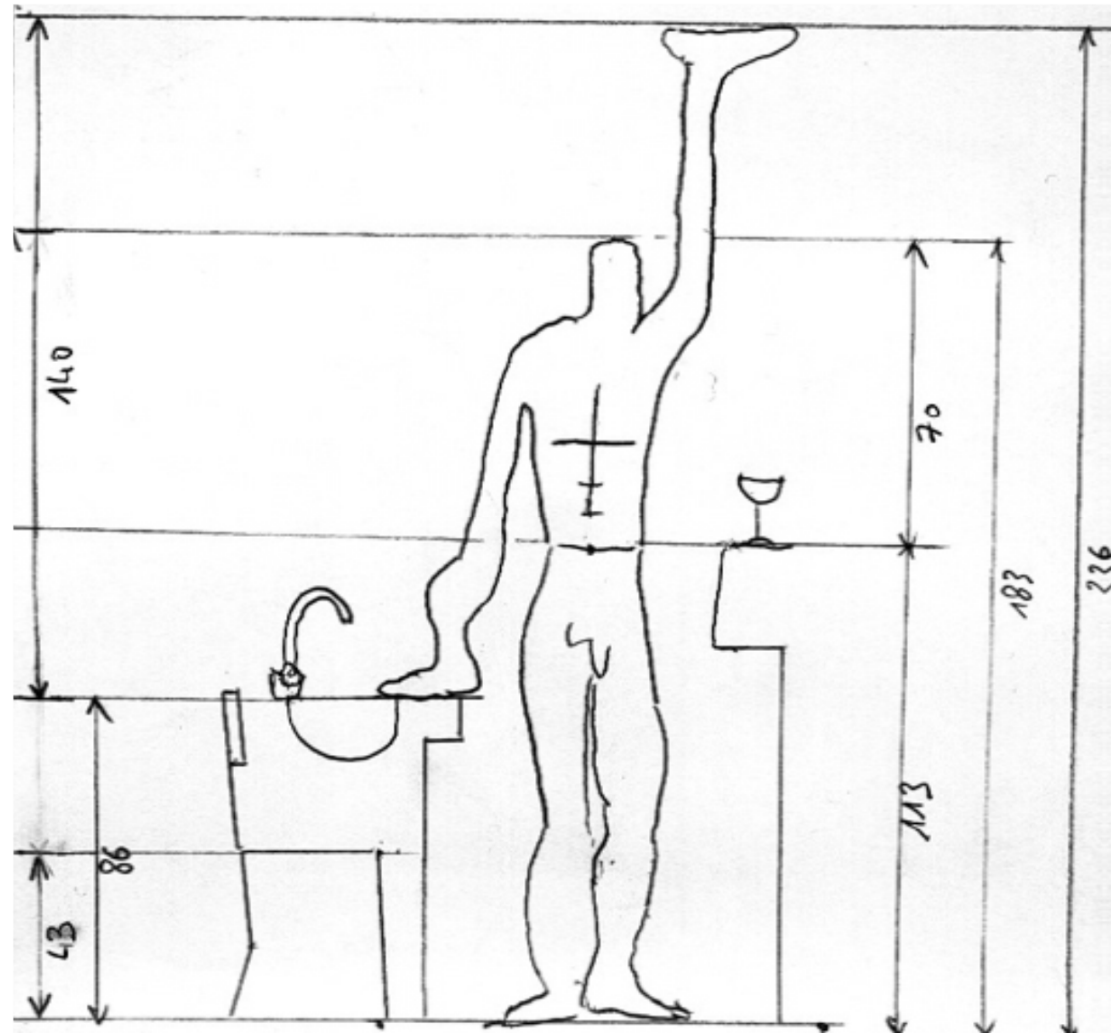
Also inspired by the Belgian statistician Quetelet's (Belgian statistician) work on the mean value published in 1844: *Sur l'appréciation des documents statistiques, et en particulier sur l'application des moyennes* (Engl translation: About the assessment of statistical documents, in particularly about applications of means).

Le Corbusier used sequences of numbers based on golden ratio used model the proportions of the human body…

Série rouge		Série bleue	
mètres	pouces	mètres	pouces
4,79	116”1/2	9,57	233”
2,96	72”	5,92	144”
1,83	44”1/2	3,66	89”
1,13	27”1/2	2,26	55”
0,70	17”	1,40	34”
0,43	10”1/2	0,86	21”
0,26	6”1/2	0,53	13”

Note:
Ignore pouches (inches), conversion doesn’t seem to be correct

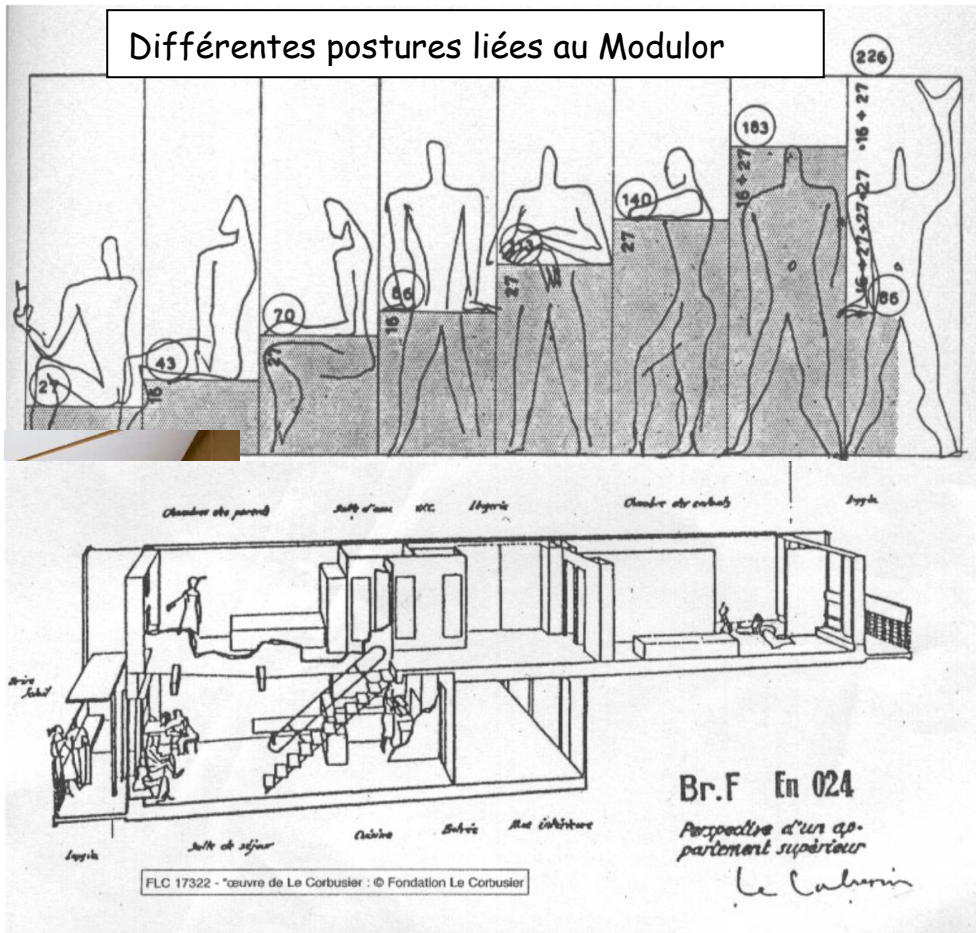




http://www.ac-nice.fr/wrne/college-gerard-philipe/wp-content/uploads/sites/28/2015/03/Le-Modulor.pdf

Models were used to design optimal flats

- Comfort, sunny, space-saving, relatively low building cost
- Facilities (store, restaurant, social space etc) part of design
- Suitable for growing European population at the time

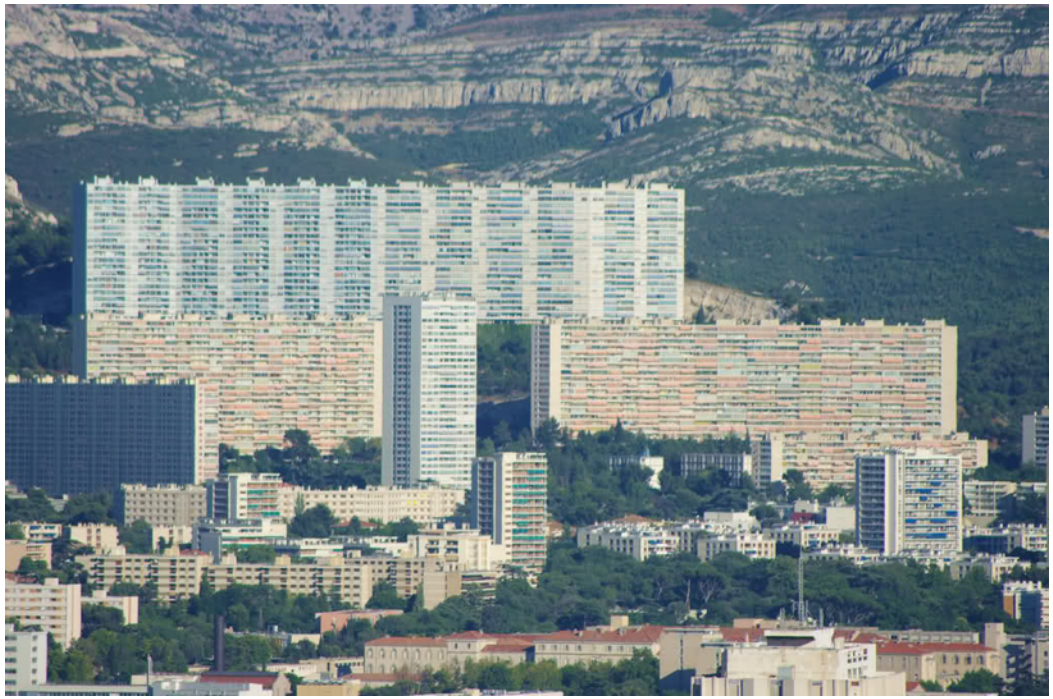


Corbusierhaus Berlin
(Engl. Transl.: Corbusier house Berlin)

https://upload.wikimedia.org/wikipedia/commons/a/af/Corbusierhaus_Berlin_B.jpg

Efficiency may go too far…

- *Les grands ensembles* (Engl. transl.: tower blocks) are linked to fundamental social crisis in France since the 1980s
- Gap between what model aimed to achieve and its consequences in the real world (here: monstrous architecture)



Quartier de La Rouvière (9ème arrondissement) Marseille

http://tinypic.com/view.php?pic=2i0udtx&s=4#.WDORxzbjlss

https://lafautealecorbusier.wordpress.com/2012/10/16/les-grands-ensembles/

More examples for normative models for humans

What are other idealised models of humans?

Part of the basis of cultures, philosophies, religions, emphasising different aspects of human nature.

Examples

- ***religions:*** spiritual interest, divine goals, moral responsibility
- ***enlightenment:*** seeking truth, scientific approach, utility maximisation through rational actions
- ***authoritarian systems:*** binary division of humanity (followers and leaders), followers agree to sacrifice personal needs to achieve order and goals defined by leaders
- ***democratic systems:*** pluralistic view of humanity, social and individual responsibility and freedom ensure innovation, cooperation and productivity

Definition: Descriptive theory

Descriptive theories of decision making

- Determine *how and why* people make decisions the way the do (rational and not rational) in real life
- No *a priori* assumptions on people's motivations and capabilities
- Methods: Empirical studies, including field studies and lab experiments
- Models: Based on empirical studies, do not have to conform to existing axiom systems
- Can explain some situations where people's behaviour is inconsistent with the normative theories.

http://epublications.uef.fi/pub/urn_isbn_978-952-458-985-7/urn_isbn_978-952-458-985-7.pdf

Methodology: Normative theory versus descriptive theory

Normative theories of decision making:

- How idealised (rational) world behave when taking decisions
- Based on an idealised form of human being
- Methods: Mathematical axioms and optimisation

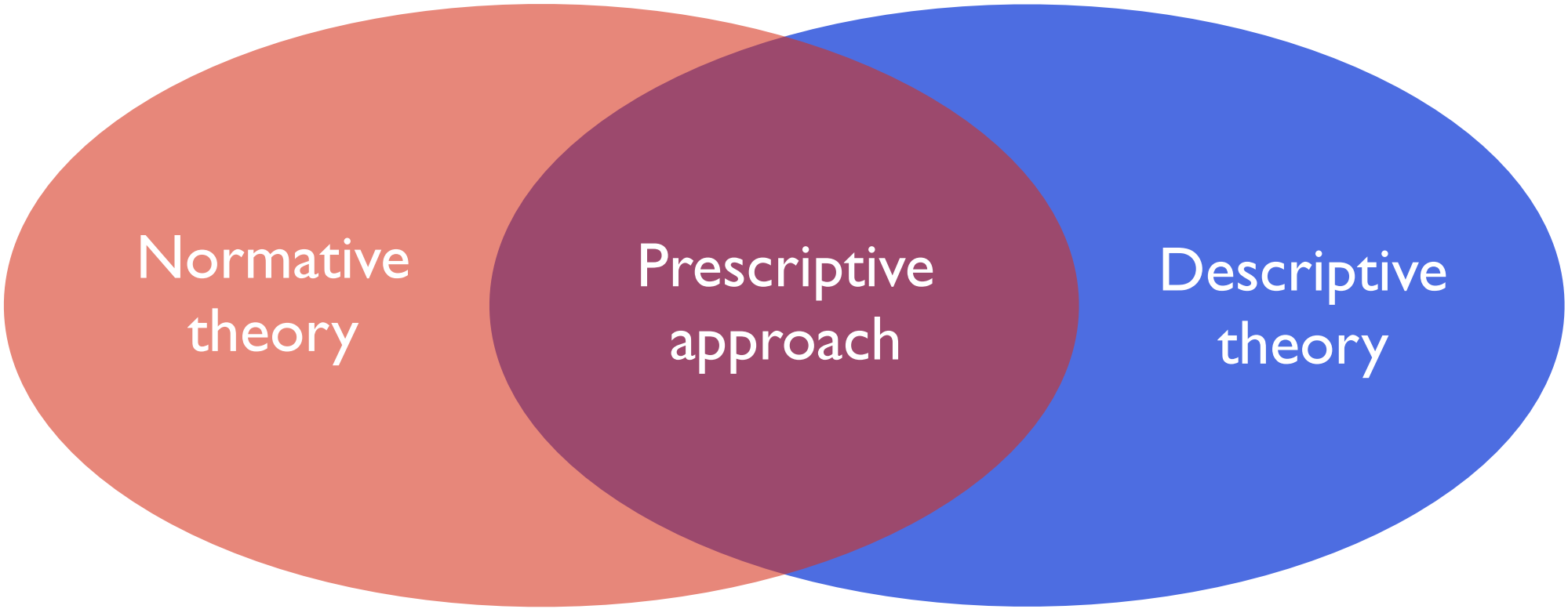
Descriptive theories of decision making

- How *people actually make* decisions
- Based on observation (empirical studies)
- Methods: empirical studies, revised models

Why is normative theory not enough?

Empirical studies have demonstrated that people do not always follow the axioms of probability (biases, fallacies, heuristics).

Methodology: Complementary theories of decision making



Why is normative theory not enough?

Empirical studies have demonstrated that people do not always follow the axioms of probability (biases, fallacies, heuristics).

Definition: Prescriptive approach

Normative and descriptive approach may be opposites.

How can they work together in practice?

Prescriptive point of view

- Purpose is to support people in making good decisions
- Give practical aids with choices
- People who are less rational, but nevertheless aspire to rationality (e.g. operation research and management science).
- Support people in emotionally stressful decisions to limit damage from temporary moods
- Decision support tools
- Education, training (e.g. CFAR, Harding centre)