Research through Design

- what is hard core science -

Matthias Rauterberg

Eindhoven University of Technology

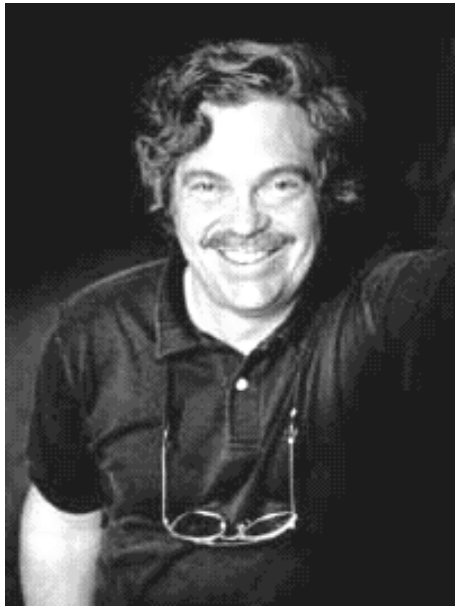
2017

Thinker versus Tinker

Ludwig Boltzmann (1884-1906)

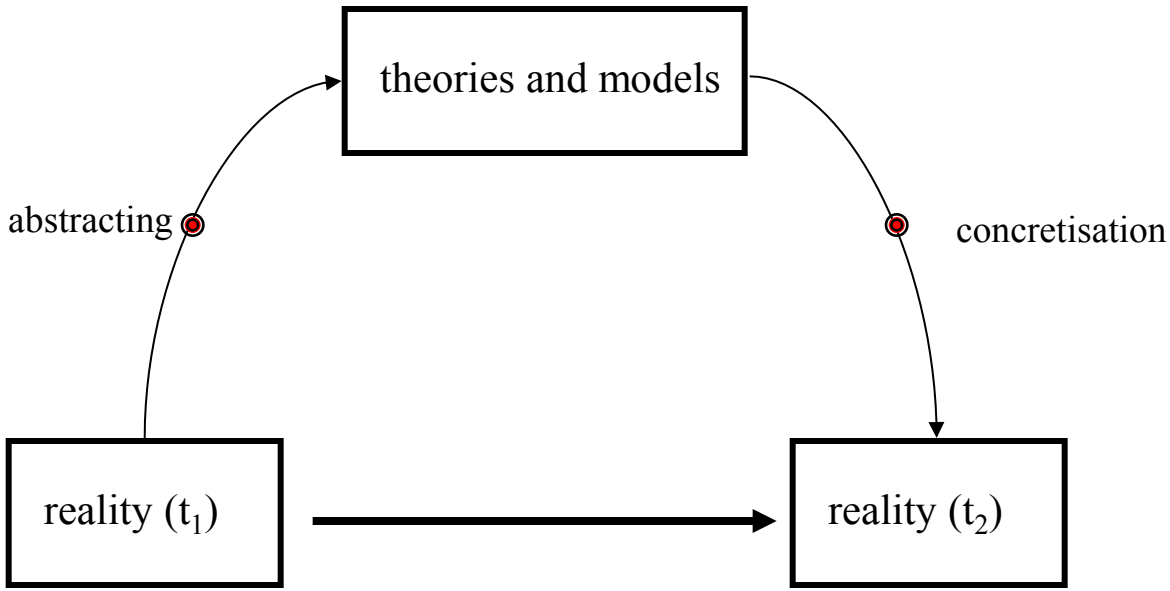
“There is nothing so practical as a good theory."

"Don't worry about what anybody else is going to do… The best way to predict the future is to invent it. Really smart people with reasonable funding can do just about anything that doesn't violate too many of Newton's Laws!" (1971)



Alan C. Kay (1940-)

How do we get theories?



positivism :

{theory, model} $\notin$ reality

reality (t_1) $\approx$ reality (t_2)

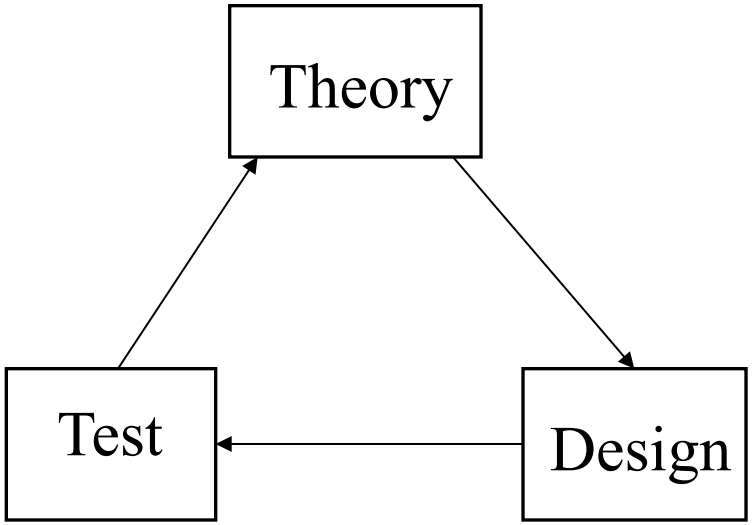
constructionism :

{theory, model} $\in$ reality

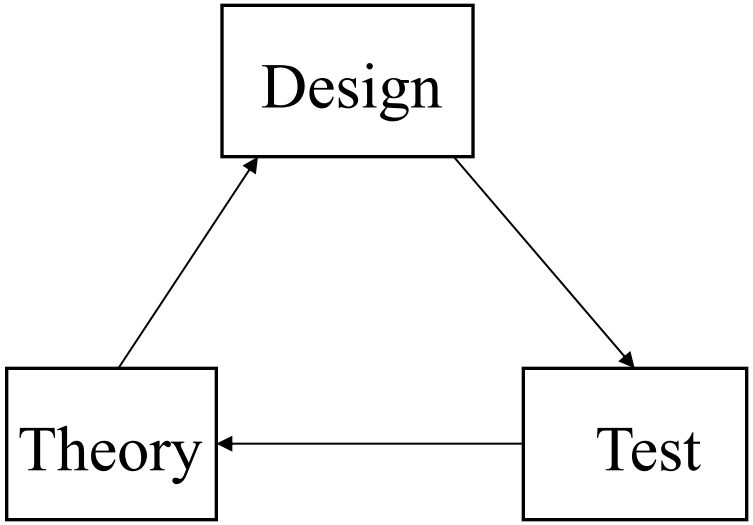
reality (t_1) $\neq$ reality (t_2)

[REF: Rauterberg M. (2006). HCI as an engineering discipline: to be or not to be!?. *African Journal of Information and Communication Technology*, vol. 2, no. 4, pp. 163-184]

What kind of knowledge?

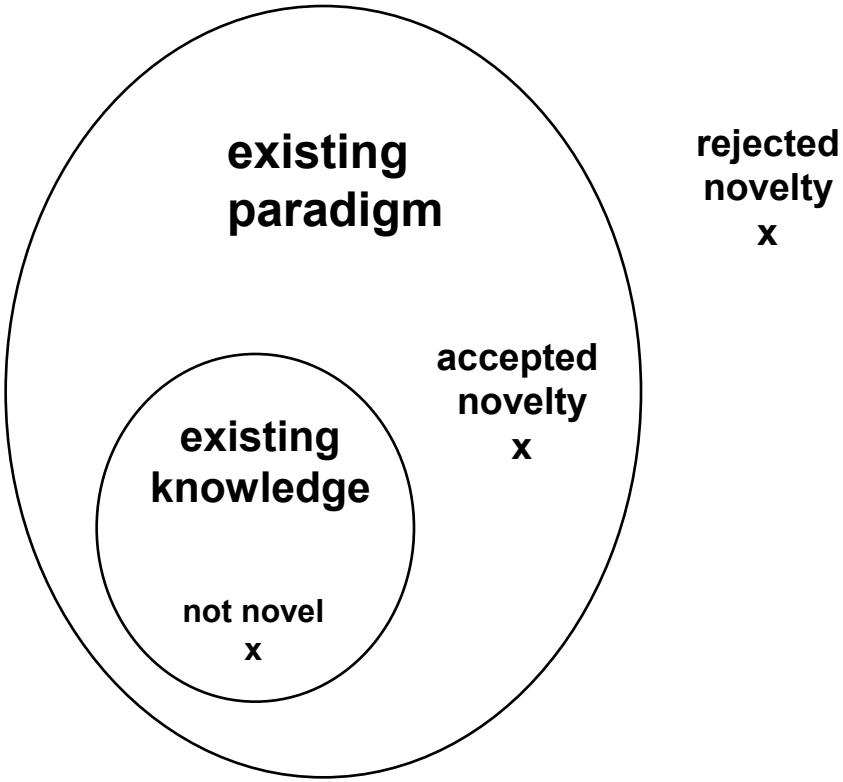


Model-T



Model-D

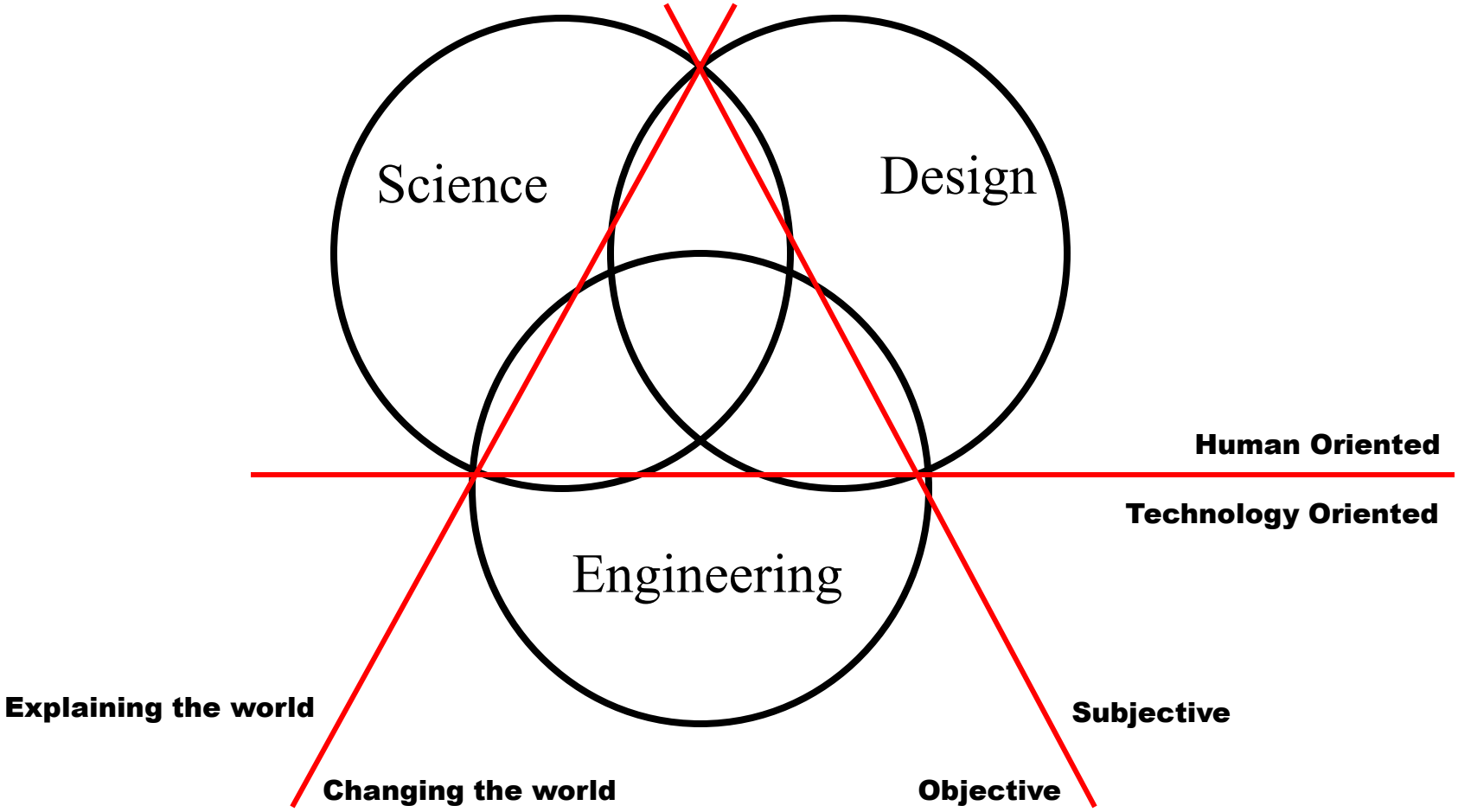
Paradigm and novelty



Paradigm is an un-questioned theory or set of beliefs, existing world-view (concept introduced by Thomas Kuhn in 1962).

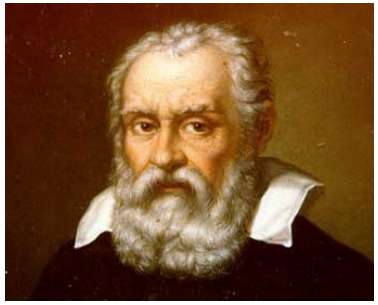
Novel results outside the present paradigm are mainly rejected by the scientific community.

Three paradigms and major barriers

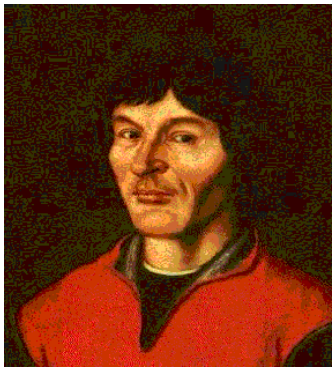


These persons really changed our world…

René Descartes
(1596-1650)



Galileo Galilei
(1564-1642)



Nikolaus Kopernikus
(1473-1543)

Leonardo Da Vinci
(1452-1519)

Christopher
Columbus
(1451-1506)

most remarkable people

A deep insight…

Arthur Schopenhauer [1788 – 1860]

“The task is not so much *to see* what no one yet has seen, but to *think what nobody* yet has *thought* about that which *everybody sees*…

But life is short, and truth works far and lives long: let us speak the truth."
(1818)

1492 – Conquest of paradise – the new world

La Vérité ("Truth")
Jules Joseph Lefebvre, 1870

So, what is TRUTH?

The meaning of the word **truth** extends from honesty, good faith, and sincerity in general, to agreement with fact or reality in particular.

The term has no single definition about which a majority of professional philosophers and scholars agree, and various theories of truth continue to be debated.

There are differing claims on such questions as what constitutes truth; how to define and identify truth; the roles that revealed and acquired knowledge play; and whether truth is subjective, relative, objective, or absolute.

From Wikipedia, the free encyclopedia

Correspondence theories state that true beliefs and true statements correspond to the actual state of affairs. This type of theory posits a relationship between thoughts or statements on the one hand, and things or objects on the other.

For **coherence theories** in general, truth requires a proper fit of elements within a whole system. Very often, though, coherence is taken to imply something more than simple logical consistency; often there is a demand that the propositions in a coherent system lend mutual inferential support to each other.

Social constructivism holds that truth is constructed by social processes, is historically and culturally specific, and that it is in part shaped through the power struggles within a community. Constructivism views all of our knowledge as "constructed," because it does not reflect any external "transcendent" realities (as a pure correspondence theory might hold).

Consensus theory holds that truth is whatever is agreed upon, or in some versions, might come to be agreed upon, by some specified group. Such a group might include all human beings, or a subset thereof consisting of more than one person.

Although there are differences in viewpoint among proponents of **pragmatic theory**, they hold in common that truth is verified and confirmed by the results of putting one's concepts into practice.

A **logical truth** (also called an analytic truth or a necessary truth) is a statement which is true in all possible worlds or under all possible interpretations, as contrasted to a synthetic claim (or fact) which is only true in this world as it has historically unfolded. Logical truths are necessarily true. A proposition such as “If p and q, then p.” and the proposition “All husbands are married.” are considered to be logical truths because they are true because of their meanings and not because of any facts of the world. They are such that they could not be untrue.

There are two main approaches to **truth in mathematics**. They are the model theory of truth and the proof theory of truth.

“But life is short, and truth works far and lives long…” Schopenhauer

“Time Saving Truth from Falsehood and Envy”
François Lemoyne, 1737

	Ontological Reference		
	Real Being	**Formal Being**	**Ideal Being**
Epistemo-logical Method	Observation of Reality	Formal proof	Belief based on intuition
Inference Concept	Inductive logic	Deductive logic	Value system
Academic Paradigm	Natural Sciences	Mathe-matics	Humane Sciences

Analysis & Synthesis, Deduction & Induction

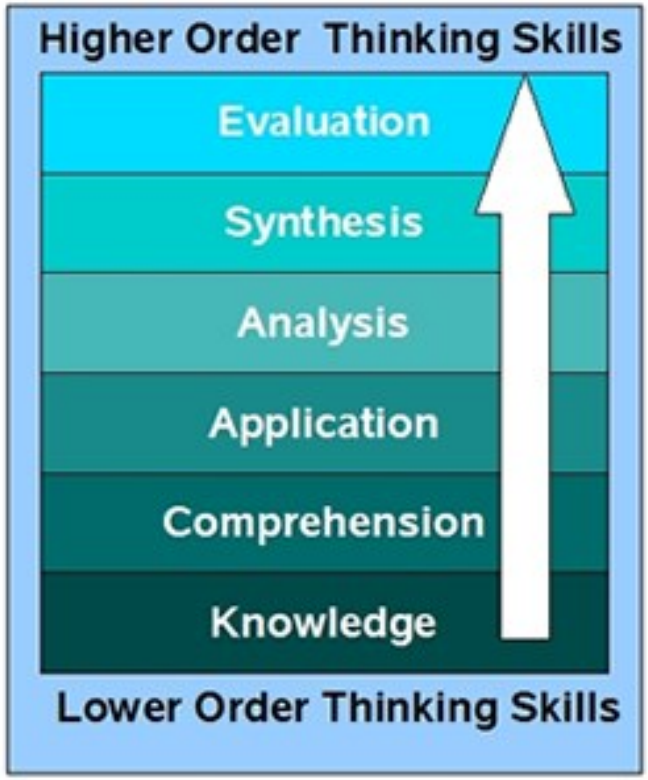
Analysis (reduction): Separating of any material or abstract entity into its constituent elements.

Synthesis: Combining of the constituent elements or separate material or abstract entities into a single or unified entity.

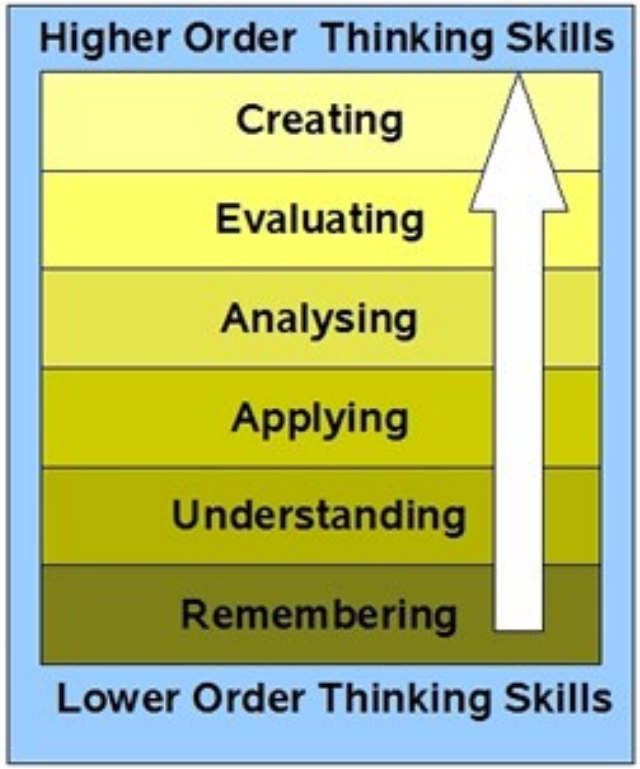
Deduction: A form of inference; if the premises are true, the conclusion must be true, i.e., deduction preserves the truth (equivalent to analysis).

Scientific induction: a form of inference in which the conclusion, though supported by the premises, does not follow from them necessarily, i.e., induction does not necessarily preserve the truth (equivalent to synthesis).

Bloom's Taxonomy



Bloom's Revised Taxonomy



Taxonomy of Educational Objectives: The Classification of Educational Goals; pp. 201–207; B. S. Bloom (Ed.) Susan Fauer Company, Inc. 1956.

A Taxonomy for Learning, Teaching, and Assessing — A Revision of Bloom's Taxonomy of Educational Objectives; Lorin W. Anderson, David R. Krathwohl, Peter W. Airasian, Kathleen A. Cruikshank, Richard E. Mayer, Paul R. Pintrich, James Raths and Merlin C. Wittrock (Eds.) Addison Wesley Longman, Inc. 2001

Causation, science and common sense

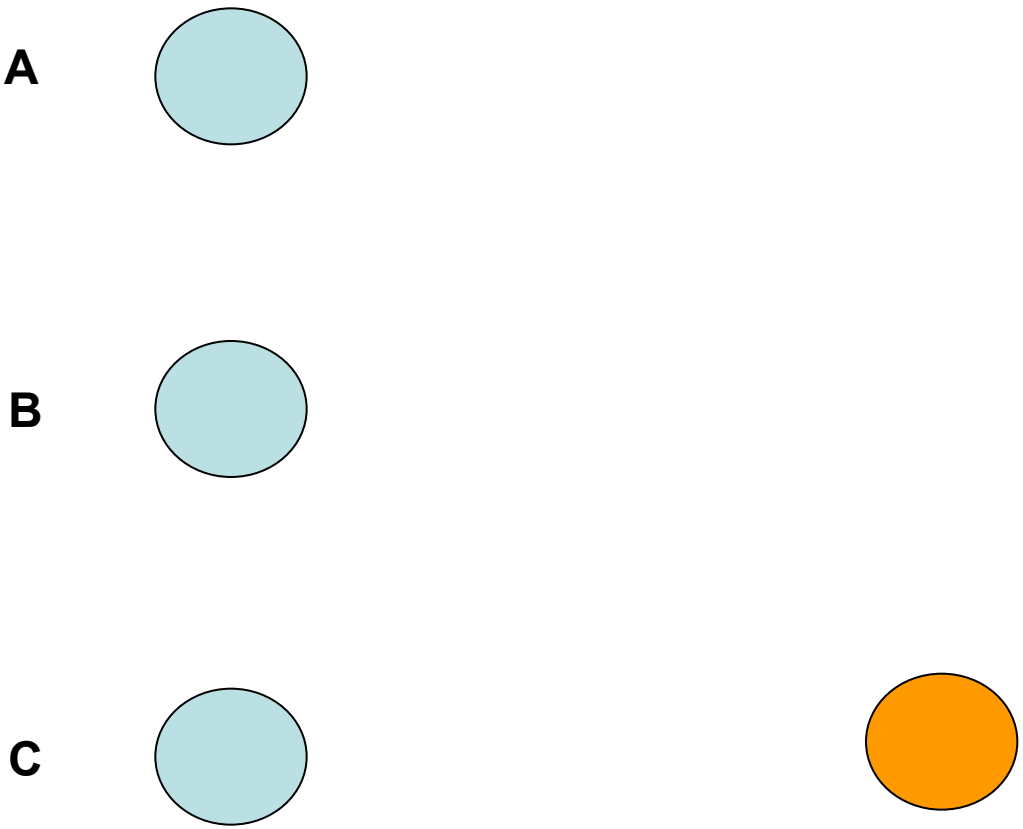
- We have a somewhat problem free handle on talk about causes, effects and causal explanations.

- Example: The beer got me so drunk that I fell down the stairs causing a fracture in my leg.

  That explains why I am moving around using these crutches.

- In science, acknowledging causes and effects is central !

What are causes and effects?



Are there causes and effects?

- We would normally not question that there are causes and effects.
- There seems to be an apparent necessity in causal relationships.
- Causation reduces to spatiotemporal contiguity, succession and constant conjunction.
- Regularities are just things or processes that we see repeated in nature.
- We have no epistemic justification for saying that they are necessary.

The regularity view of causation

- *c* causes *e* iff

  (I) *c* is spatiotemporally contiguous to *e*

  (II) *e* succeeds *c* in time, and

  (III) all events of type *C* (i.e., events that are like *c*) are regularly followed by or constantly conjoined with events of type *E* (i.e. events like *e*)

  (This formulation can be found in Psillos, 2002, p.19)

- Our ‘received view’ of causation tells us that causation happens in virtue of ‘something else’.

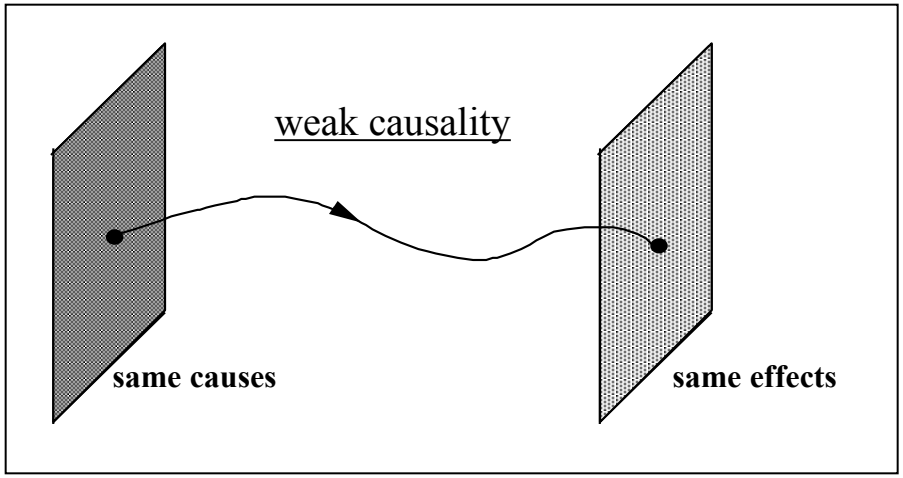
- If *c* causes *e*, it is because there is some real connection between *c* and *e* (that necessitates *e* happening when *c* happens).

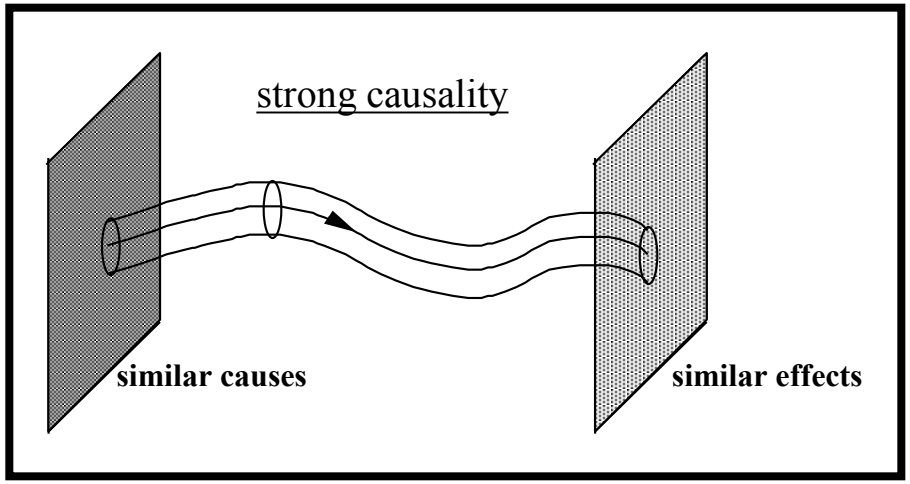
Similarity between worlds and causation

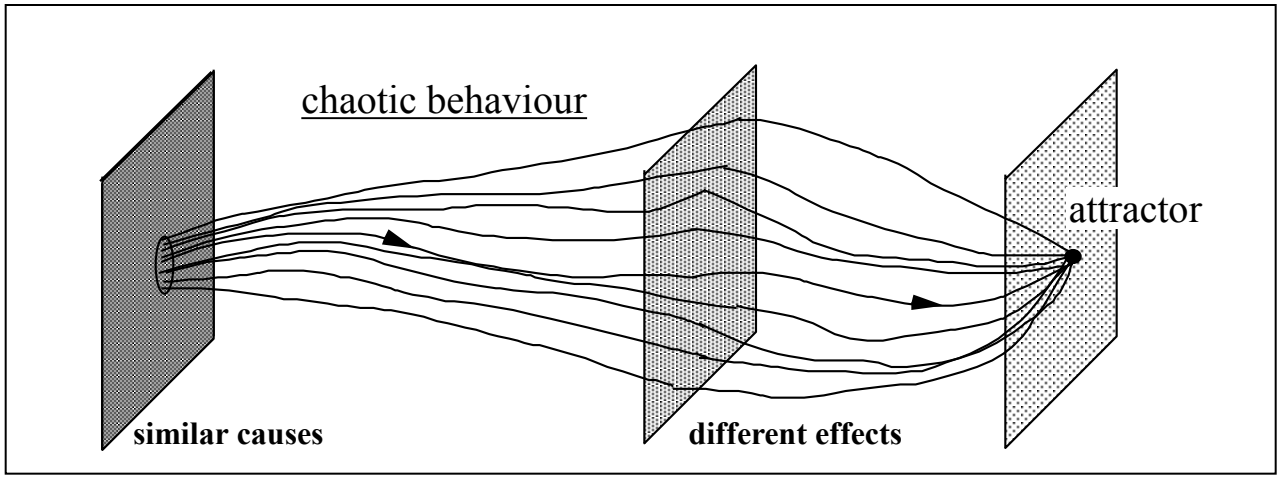
- We evaluate worlds with regard to matters of fact and laws.
- Some of these matters of fact will be causal.
- Laws of nature are sometimes considered to be causal.
  - Whether objects fall to the ground will depend on whether they are supported.
  - How far you can jump will depend on whether the laws of gravitation hold.
- So, when we determine the **truth conditions** for certain counterfactuals we already have to assume that certain causal facts either obtain or do not obtain in the worlds we evaluate with regard to their similarity.

Three kinds of causality

[Walter Seifritz (1987), Wachstum, Ruckkopplung und Chaos:
Eine Einfuhrung in die Welt der Nichtlinearitat und des Chaos . Carl Hanser]



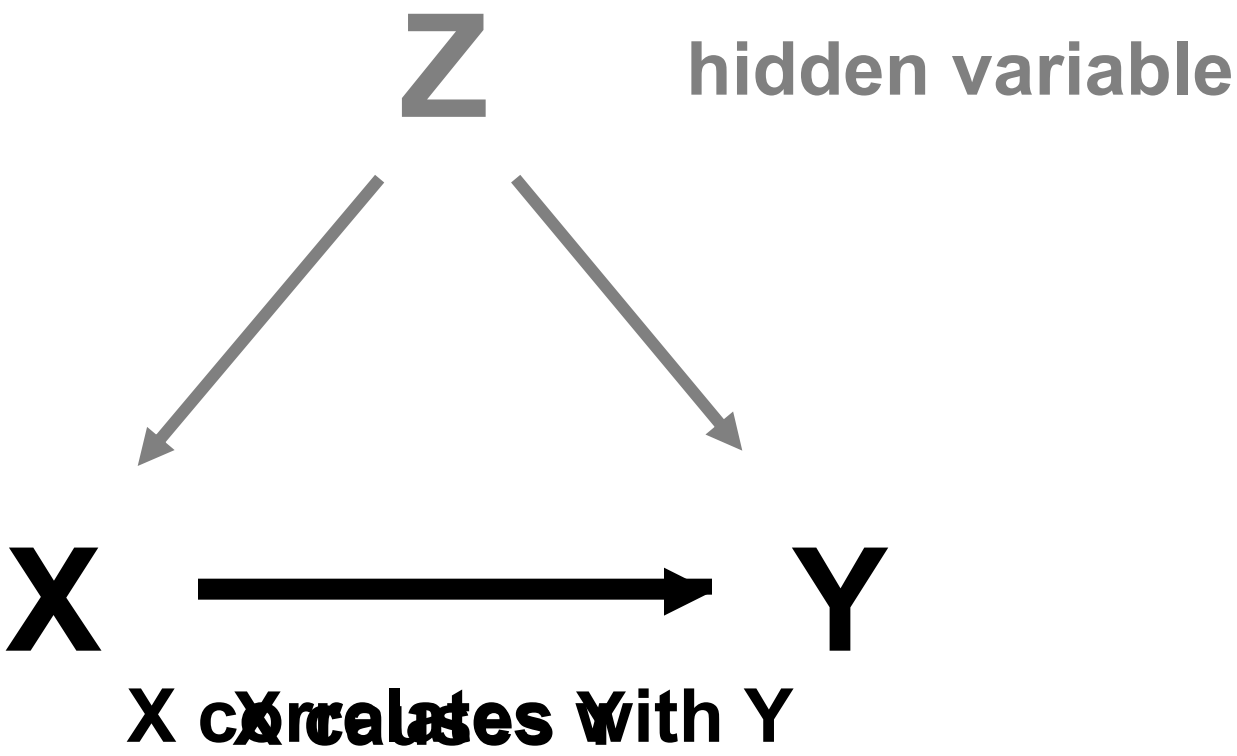




To explain the world, we need to know…

- The cause(s) -- effect(s) relationship(s)
- Factors altering functional relationships
- Systematic context for that information

The basic idea in explaining the world…



REF: Robert Mauro, Understanding L.O.V.E. (Left Out Variables Error): A Method for Estimating the Effects of Omitted Variables. *Psychological Bulletin*, Volume 108, Issue 2, September 1990, Pages 314-329

Positivistic sciences

- An assumption of linear causality; there are no effects without causes and no causes without effects. [***Causality***]
- A single, tangible reality "out there" that can be broken apart into pieces capable of being studied independently. [***Reductionism***]
- The separation of the observer from the observed. [***Objectivity***]
  - So that the results of an inquiry are essentially free from beliefs, interpretations, etc.
- What is true at one time and place will also be true at another time and place. [***Universality***]

Principle of the minimum

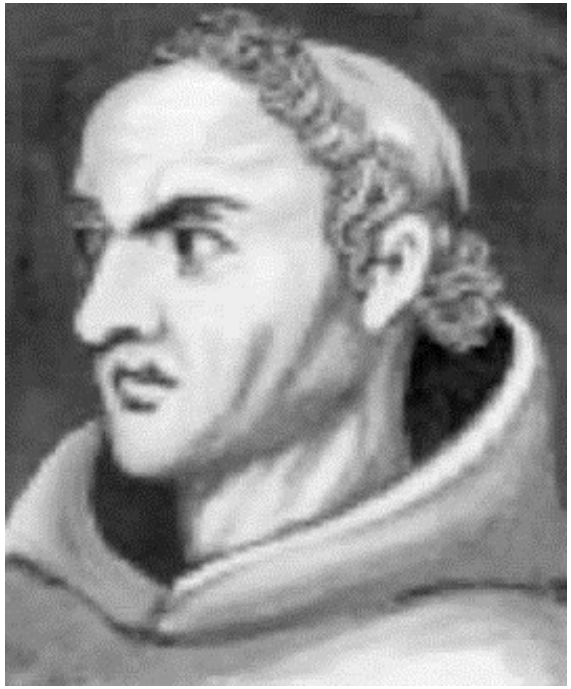
“Ockham’s razor”:

- Elimination of superfluous concepts

  (*pluralitas non est podenda sine necessitate*)

- Scepticism

- Omnipotence principle



William of Ockham
(c.1280 - c.1348)

Criteria for scientific theories

Agreement with data

- Falsifiability (hypothetico-deductive method)
- Repeatability and reproducibility

Coherence or unity

- Internal and external coherence
  (deductive structure)

Generality

- Parsimony or economy
  (Occam's razor to find the simplest theory)

Fertility

- New implied discoveries

A scientific method is…

"a method of research, in which a problem is identified, relevant data are gathered, a hypothesis is formulated [= discovery], and the hypothesis is empirically tested [= verification]" [Random House 1999]

- *Problem* is a question proposed for solution or discussion.

- *Hypothesis* is a provisional theory suggested as a solution to the problem: either a causal or a non-causal correlation between variables.

Scientific methods

Nomothetic research (in natural sciences and engineering): the aim is to find general causal laws to explain phenomena, theories are usually axiomatic (deductive) systems or sets of models.

Constructive research (in engineering and design): the solution of the problem is not only shown to exist but it is also constructed.

Idiographic (ideographic) research trying to provide all possible explanations of a particular case, for example in history.

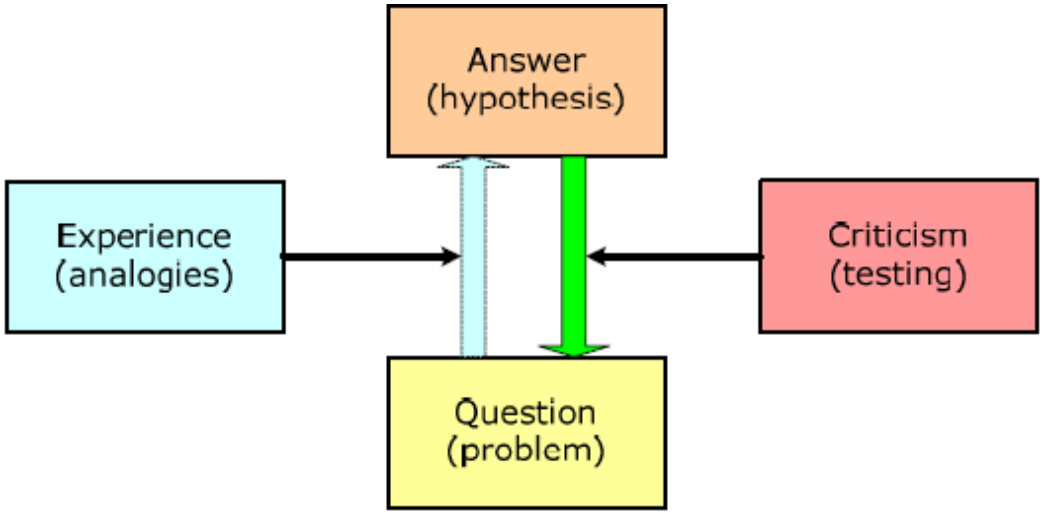
Scientific methods (cont'd)

Action research (in design sciences): the problem is solved by certain actions whose consequences are evaluated and new actions are specified (iterative improvement, trial and error).

Case study (in design sciences): an in-depth, longitudinal examination of a single instance or event, which is called a case.

Questionnaire study (in social sciences): a series of questions are used for the purpose of gathering information, which is usually analyzed statistically.

From question to answer



Discipline	Question	Answer
Mathematics	Problem	Conjecture
Science	Problem	Hypothesis
Engineering research	Problem	Solution
Engineering research	Objective	Goal
Development	Requirement	System specification

Now the big question is…

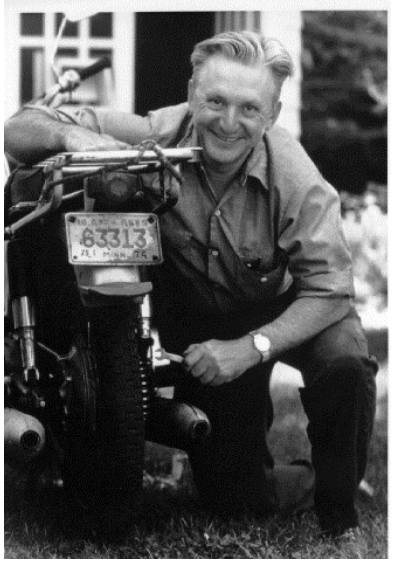
How to distinguish between
a *causal* correlation
and
a *non-causal* correlation?

Answer: the controlled experiment !

Thank you for your attention…

“Traditional scientific method has always
been at the very best 20-20 hindsight.
It’s good for seeing where you’ve been.
It’s good for testing the truth of what you
think you know, **but**
it can’t tell you where you ought to go.”

Robert Pirsig, 1974
“Zen and the art of motorcycle maintenance”



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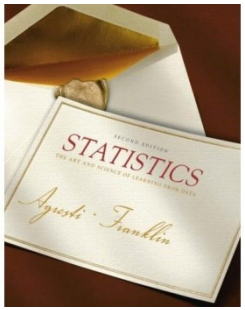
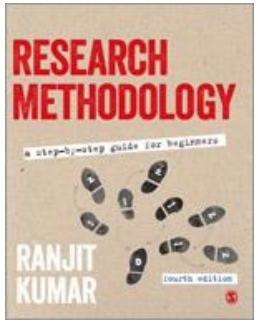


Statistics: The Art and Science of Learning from Data.
by Alan Agresti (Author), Chris Franklin (Author)
Hardcover: 848 pages
Publisher: Prentice Hall; 3 edition (2013)
Language: English
ISBN-13: 9780321755940



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by Ranjit Kumar (Author)
Hardcover: 432 pages
Publisher: SAGE Publisher; 4 edition (2014)
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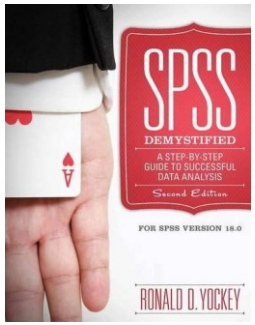
ISBN-13: 9781446269978



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by Ronald D. Yockey (Author)
Paperback: 186 pages
Publisher: AbeBooks; 2 edition (2010)
Language: English
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by Brenda Laurel (Editor), Peter Lunenfeld (Preface)
Hardcover: 334 pages
Publisher: The MIT Press (October 1, 2003)
Language: English
ISBN-10: 0262122634
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Social Research: Theory, Methods and Techniques.
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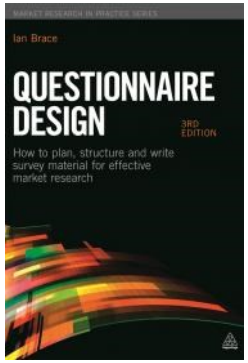

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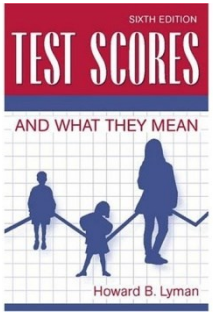

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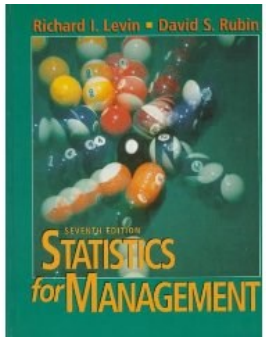
ISBN-13: 978-0205175390



Statistics for Management.
by Richard I. Levin (Author), David S. Rubin (Author)
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Language: English
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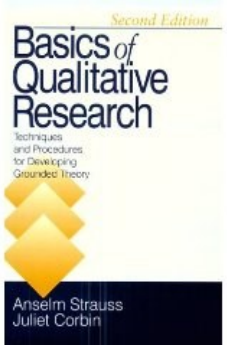
ISBN-13: 978-0134762920



Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory.
by Anselm C. Strauss (Author), Juliet Corbin (Author)
Paperback: 336 pages
Publisher: Sage Publications, Inc; 2nd edition (September 22, 1998)
Language: English
ISBN-10: 0803959400
ISBN-13: 978-0803959408