the reliability of Defective information in the sciences

[Sessions 1 and 2]

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Nicolaus Copernicus University in Toruń, Toruń, Poland. 17, February 2022

Let’s start with an example…

Contradiction is a pair of propositions where one is the negation of the other. Traditionally, contradictions have a negative connotation; in epistemology, they are often conceived as indicators of lies and epistemic errors (Cf. Moore 1942), and in logic, they are linked to paradoxes and logical triviality (Cf. Bar-Hillel 1964).

- Moore, G. E., 1942, “A reply to my critics”, The Philosophy of G. E. Moore, edited by P. A. Schilpp. Evanston, IL: Northwestern University.

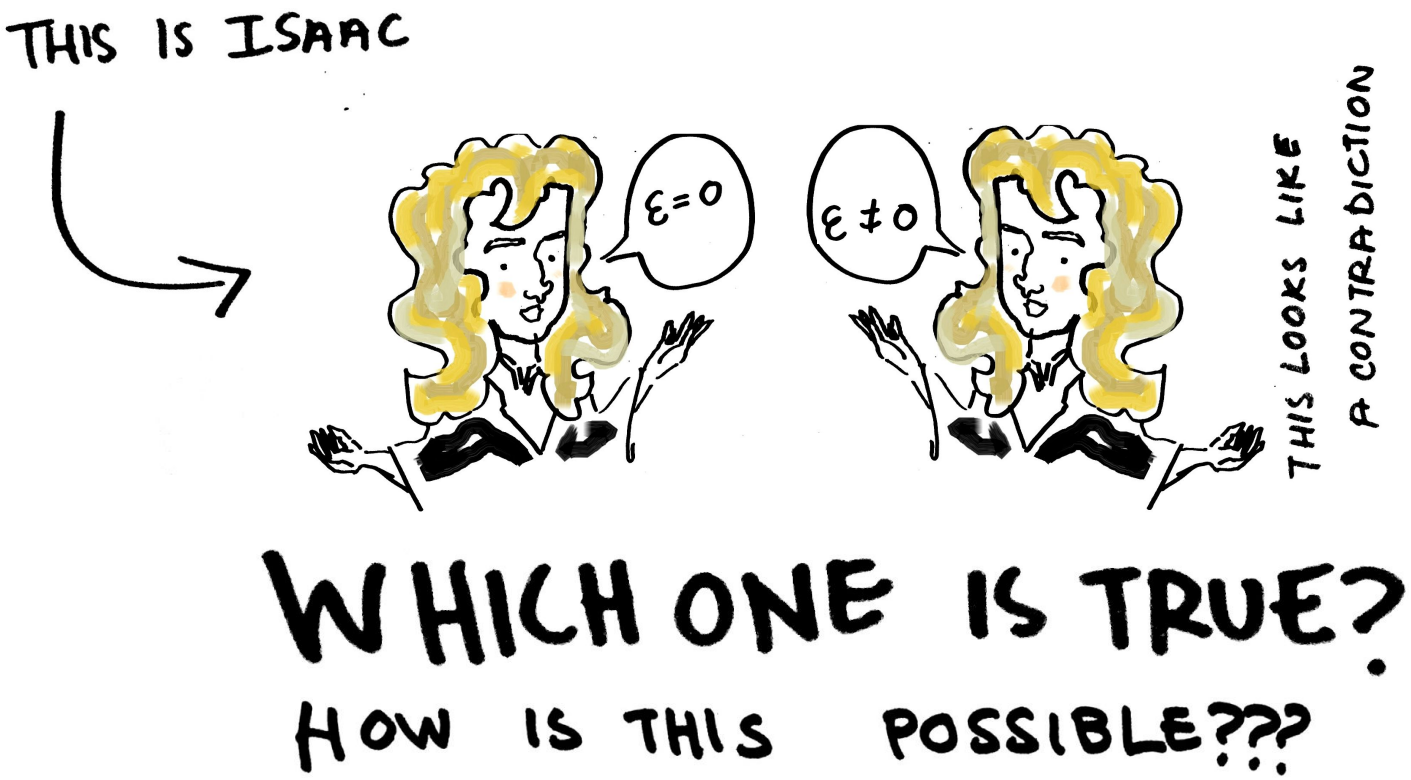
According to Berkeley (1734), in *Principia* (1687), Newton characterized infinitesimals inconsistently; this is, Newtonian infinitesimals were entities that, at some points in a particular proof, were equal to zero and, at some other points, they were different than zero.

- Berkeley, G. (1734): \textit{The Analyst}, online edition (http://www.maths.tcd.ie/pub/ HistMath/People/Berkeley/Analyst/).

  This edition edited by David R. Wilkins.

When having two scientific statements that contradict each other, scientists tend to assume that, at least, one of them is false (Laudan, 1977: 56).

- Laudan, L. (1977). *Progress and its Problems.* Ewing, NJ: University of California Press.



Plan session 1 (Phil sc)

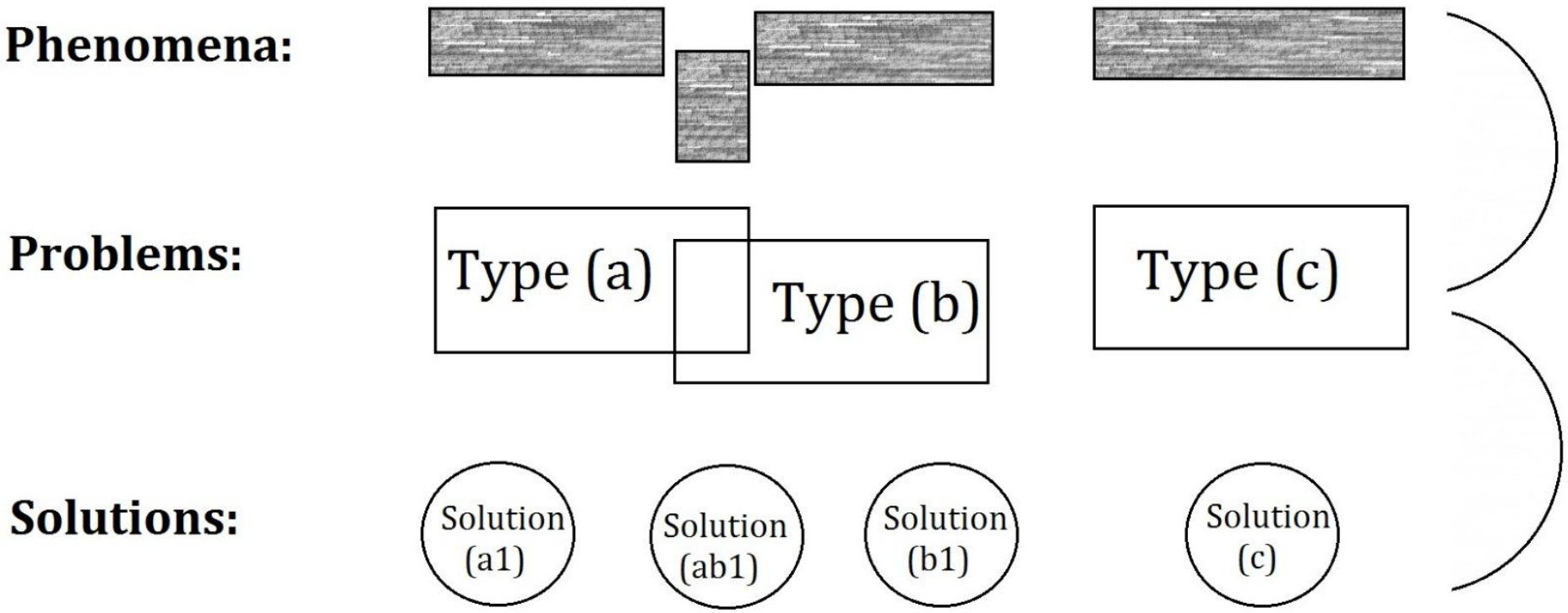
0. Preliminaries

1. Generalities of defective data
2. Unreliability of defective data
3. Toleration of defective data
4. Case study 1

Preliminaries: Science, problems, reasoning, etc.

Science

Problem solving enterprise



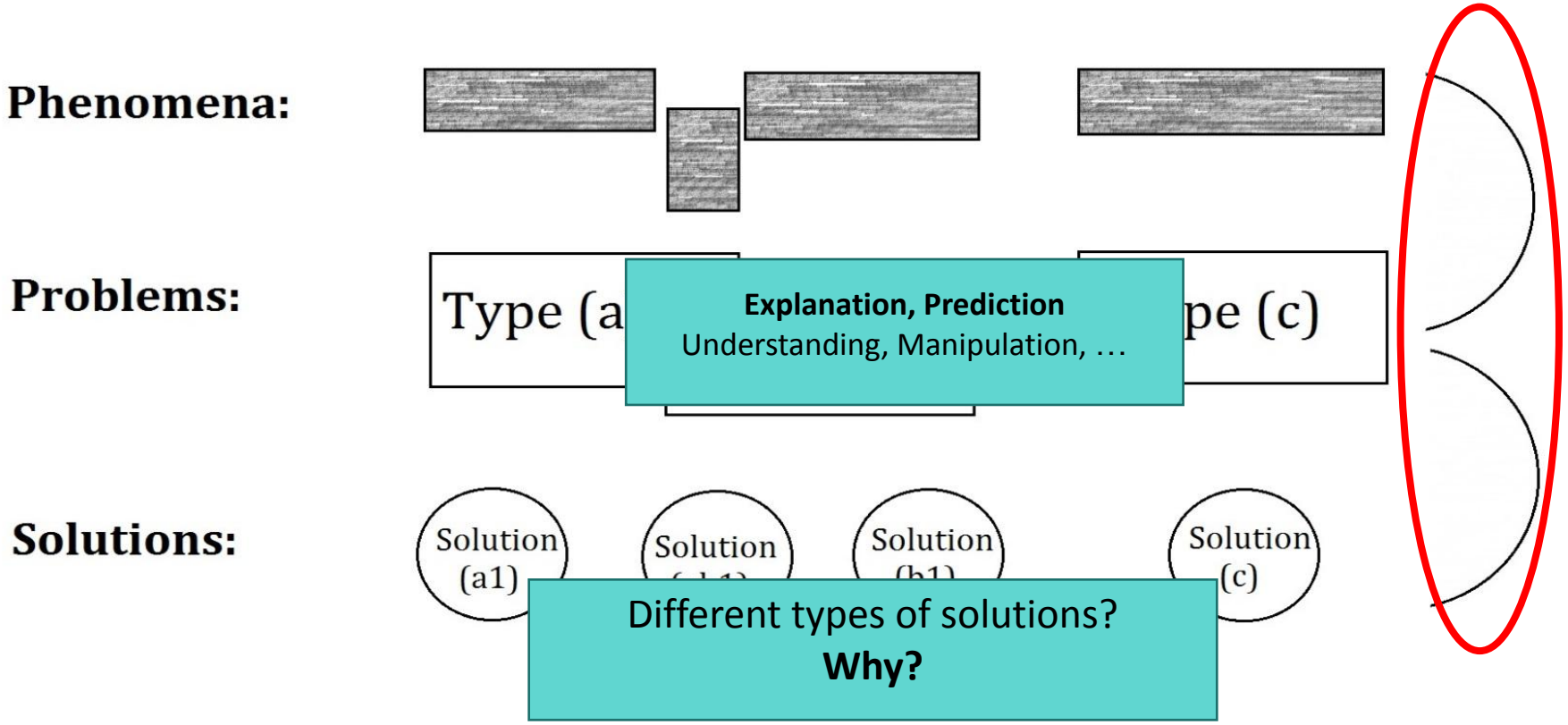
Science

Scientific Problems (Laudan 1977)

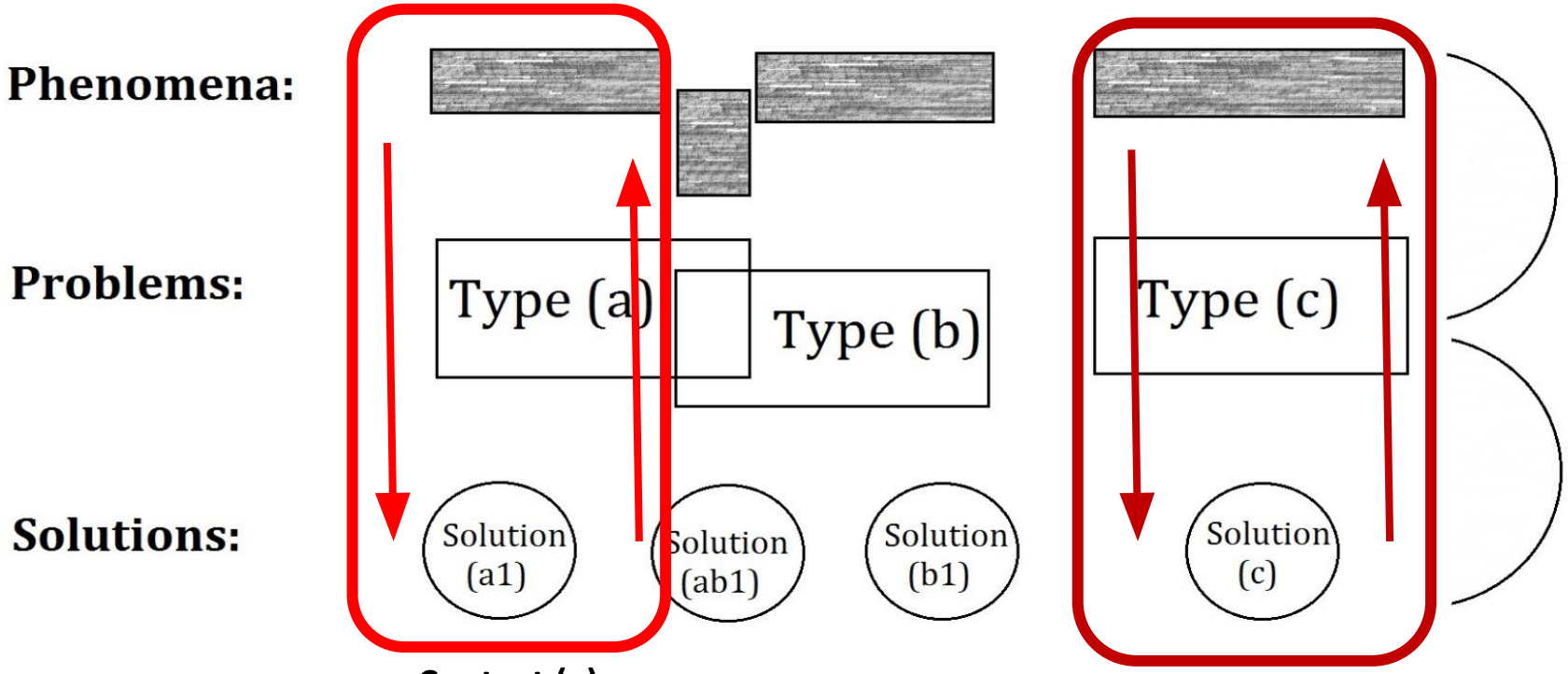
- Empirical
- Conceptual

- Laudan, L. (1977). *Progress and its Problems.* Ewing, NJ: University of California Press.

- Which type of relation holds between them?



- Which type of relation holds between them?



Context (a)
(a)- rules, (a)-standards, …

Context (b)
(b)- rules, (b)-standards, …

Defective information: whose problem is it?

Is it about the theory/model?

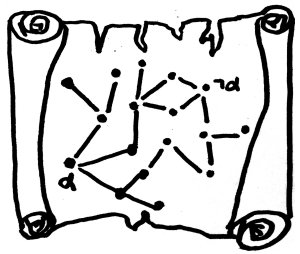
Is it about scientific reasoning?

Is it about our beliefs about the theory or the domain?

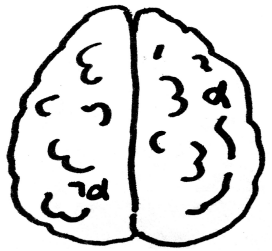
- What do we mean by *Scientific Reasoning*?

Structure of the Theory

Agent's beliefs



Inferential Procedures



Sensible Reasoning

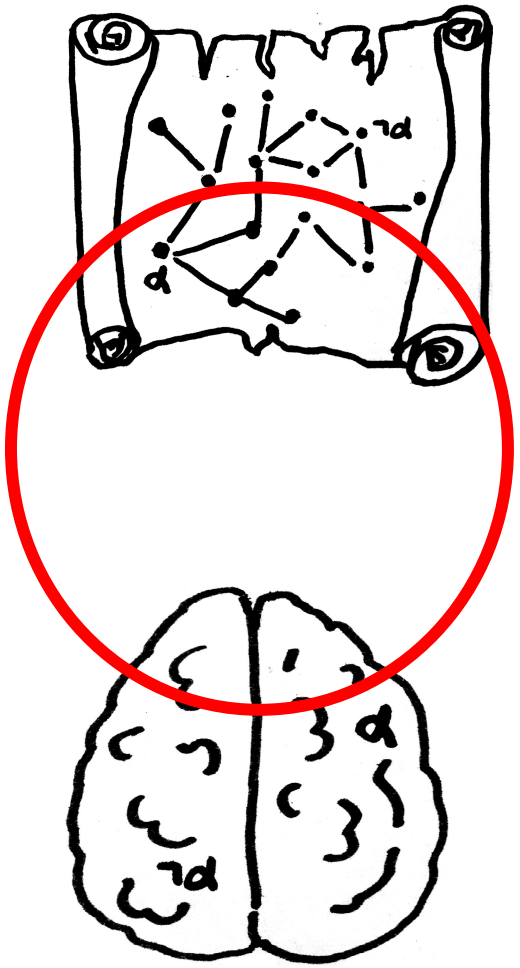
Agents are still able to distinguish between the (inferential) products of their reasoning that are sensible given a particular context from those that are not.

Successful inferential patterns

- Chains of inferences that help to achieve particular goals in an optimal way, and what is optimal depends on the phenomenon that is being studied, different types of reasoning aim at different goals.

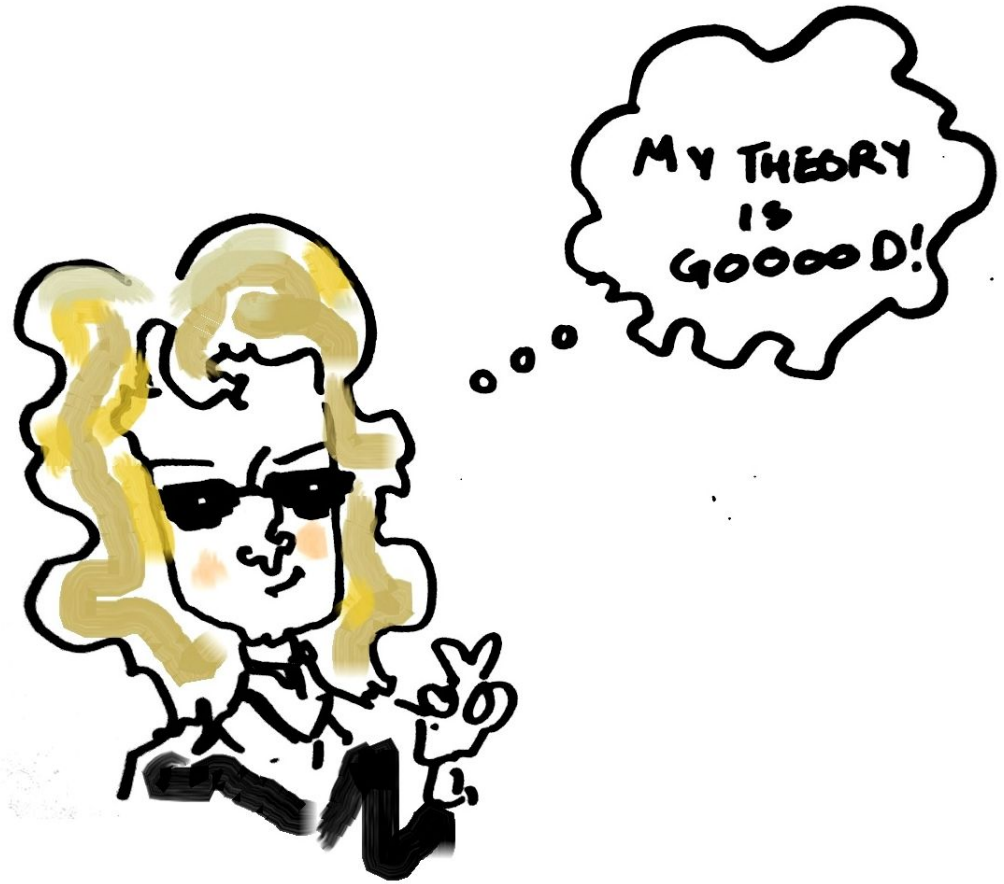
What are inferential patterns in science? (I)

Relation between beliefs/statements/groups of propositions/(…)



further tasks

- Example
  - **Type of defect, why is it problematic**
  - **Reasoning involved in the handling of the problem** <how scientists reacted to it?>
  - **How do we explain it** <which is the 'outside' explanation of what happened?>



Generalities of defective data: Inconsistency and incompleteness

Defective data

Defective information is an umbrella term that covers cases of **partial, vague, incomplete**, **conflicting and inconsistent** data. In the sciences, scientific information is often defective.

And although there are good reasons for still aiming for accurate, empirically supported and relevant information, the defective character of scientific data is not only ubiquitous, but inevitable. In light of this, philosophers and logicians of science have aimed at explaining both the presence and tolerance of defective data in scientific contexts.

Defective data: **Inconsistency**

Inconsistency: A proposition A is either self contradictory or it contradicts one of the basic principles of the set of data.

- **Example:** The square is purely white and purely black
- **Example:** Energy can be created/destroyed in an isolated system.

***Inconsistency*:** Some sentence A together with a sentence B are derivable from the same set of data, and there is a way to interpret B as the negation of A.

- **Example:** The behaviour of the atomic nucleus is classical; the atomic nucleus exhibits a quantum behaviour.

Defective data: **Inconsistency**

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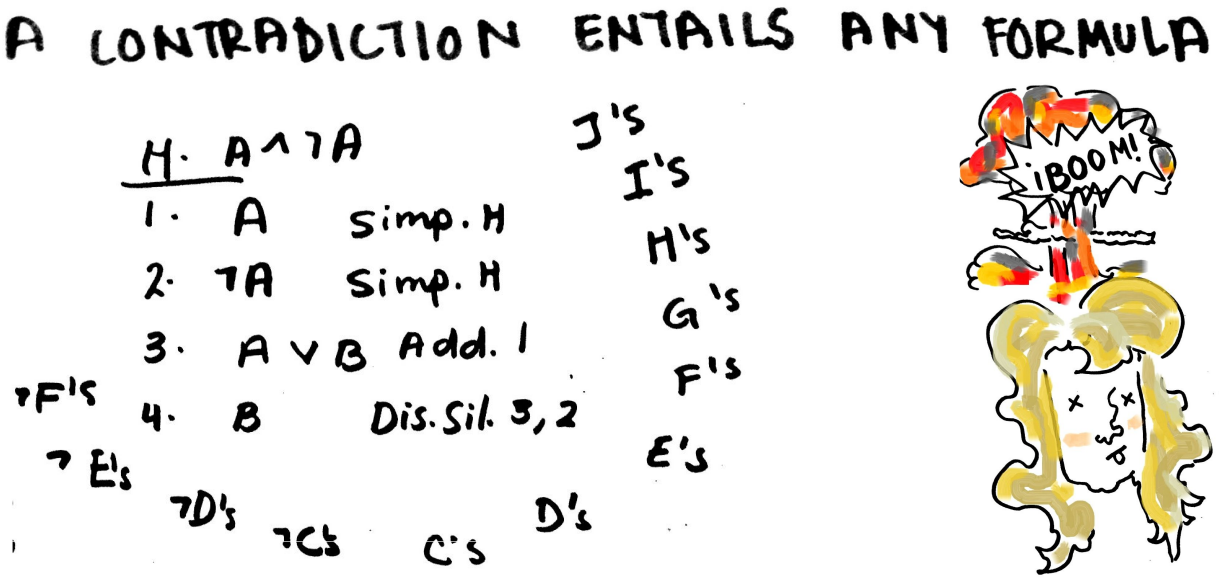
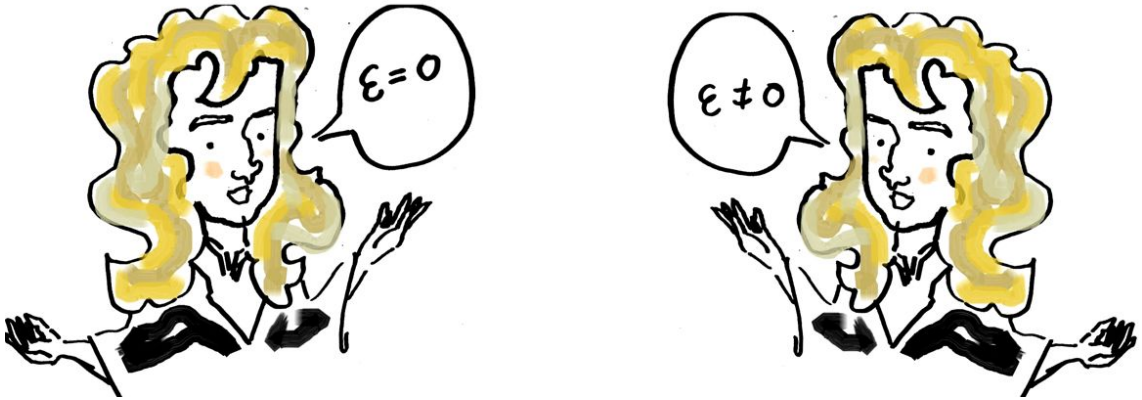




THIS LOOKS LIKE

A CONTRADICTION

LOGICALLY FALSE

Defective data: **Incompleteness**

Incompleteness: A proposition A is incomplete if it does not contain all the information needed to determine whether it is true or not within a particular theory/to describe accurately a particular phenomenon.

- **Example**: More than one type of neutrino exists.

Incompleteness: The fact that neither A and B are derivable, but at least one of them is expected (and desirable) to be obtained.

- **Example**: Mercury is located in X or there is a planet that exists in an orbit between Mercury and the Sun.

- The distinction between partial, vague, conflicting, and inconsistent is a matter of degree of lack/excess of information.

Anomalies

- Logical contrad

  Prediction
  Observational report that **contradicts** the prediction

- Lacunae

  Predictive/explanatory gaps

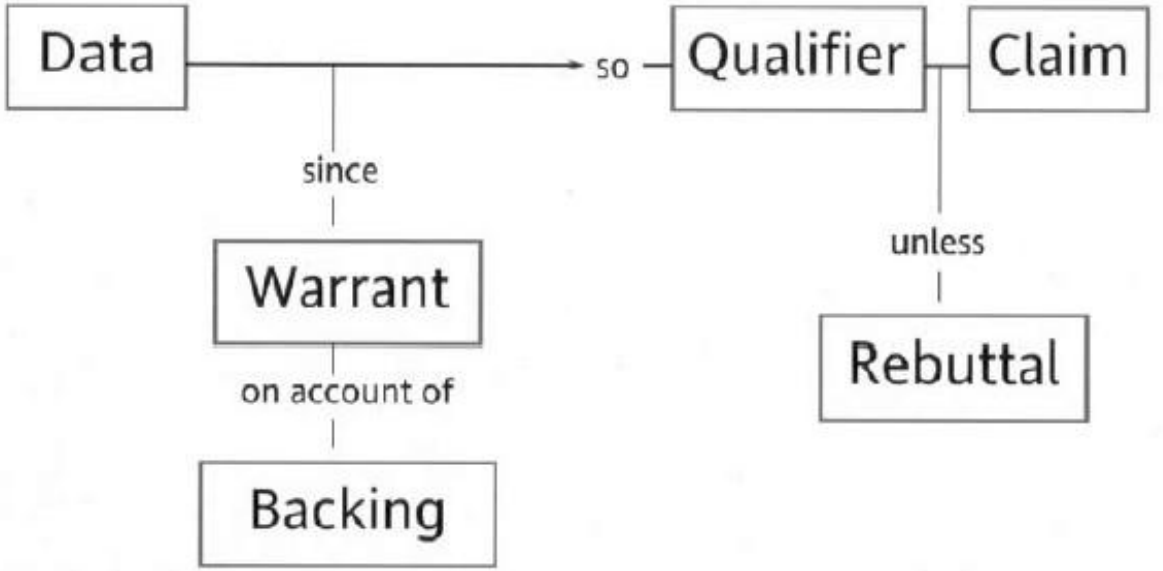
- The challenges associated with each defect are both
  - **epistemic**: use of unreliable information, trust false statements, not enough evidence in favor of particular beliefs, weak explanations, etc.
  - and **logical**: irrelevant outputs are drawn, logical explosion, triviality, no sensible reasoning.

- **Which are the sources of the defects?...**

Science communication task:

Take Toulmin's model and consider the different ways in which the presence of defects can damage the presentation and defense of scientific arguments…

Figure 1. Toulmin's Argument Pattern



Source: Toulmin (1958)

Unreliability of defective data: The epistemology

Where are the defects coming from?

Ignorance

Traditionally, ignorance has been understood as *lack of knowledge*. In this sense, one can be ignorant via the non-satisfaction of any of the basic conditions for knowledge.

This is, by failing at fulfilling a doxastic condition (believes that *p*), an alethic condition (*p* is true), a justificatory condition (believes that *p* with justification) or a Gettier-proofing condition (*S*'s justification for believing that *p* must withstand Gettier-type counterexamples) (Cf. Le Morvan and Peels, 2016: 18).

Where are the defects coming from?

Following such characterization, ignorance is often classified in, at least, the following types:

- (i) **absence of factual knowledge**: This type of ignorance conflicts with scientific reasoning by limiting the application of certain inferential rules.

- (ii) **absence of objectual knowledge**: Preventing agents to connect lists of properties to a particular object.

- (iii) **absence of procedural knowledge**: This ignorance conflicts with scientific practice especially in experimental contexts. For example, consider a scenario in which all members of a particular scientific community are ignorant of how to reproduce an experiment in order to validate other team's reports; this absence of procedural knowledge becomes an impediment for the other team's results.

- (iv) **absence of knowledge of theoretical structure**} Ignorance of theoretical structure is often the cause of persistent instances of any of the other types of ignorance. Lacking access to a relevant part of the structural conditions of a theory prevents scientists from either inferring the value of certain proposition (causing factual ignorance), identifying whether distinct sequences of properties refer to the same object (causing objectual ignorance) or explaining inferential procedures (causing procedural knowledge) (Cf. Martínez-Ordaz 2020).

Orthogonally, one can also recognize (v) *erotetic ignorance* -absence of answers to questions.

Ignorance of theoretical structure

Lacking knowledge of the (relevant) inference patterns that scientific theories allow for. When ignoring (the relevant parts of) the theoretical structure of a theory, scientists are not capable of grasping abstract causal connections between the propositions of their theory, they can neither identify the logical consequences of the propositions that they are working with nor can explain under which conditions the truth value of such propositions will be false. (Martínez-Ordaz 2020: 12)

Factual ignorance

Failure at assigning an alethic value to *x*

What else is affected by ignorance?

Epistemic reliability

Epistemic trust vs Epistemic reliance

Epistemic trust (Cf. Wilholt 2013)}

How do we justify our trust in something/someone?

- **Truth-directed:** An agent *S*' trust in *x* is rational only if *S* has gathered enough evidence that supports the claim<<*x* is trust-worthy>>.
- **End-directed:** *S* will be rational when trusting *x*, if to assume the trustworthiness of *x* plays an essential role for *Y*, and *Y* is *S*' goal in the relevant context (Cf. McLeod 2020: Sec. 2.1).

Epistemic reliance

From a reliabilist point of view, to be justified in believing that *x*, an epistemic agent does not need to have epistemic transparency regarding every step of the process that was relevant to form the belief that *p*; nonetheless, she must have **evidence in favor of the reliability of the process itself** (cf. Goodman and Beddor 2021).

- The distinction between partial, vague, conflicting, and inconsistent is a matter of degree of lack/excess of information.

- The challenges associated with each defect are both
  - **epistemic**: use of unreliable information, trust false statements, not enough evidence in favor of particular beliefs, weak explanations, etc.

  - and **logical**: irrelevant outputs are drawn, logical explosion, triviality, no sensible reasoning.

- **Which are the sources of the defects?...**

Epistemic transparency

- A process is epistemically opaque to a cognitive agent X at time t just in case X does not know at t all of the epistemically relevant elements of the process“ (Humphreys 2009: 618).

- Transparency is often achieved when an agent can know when a step in the procedure is relevant (weak transparency) as well as when when it is not (strong transparency)

Toleration of defective information

Tolerance

What are we doing?

Accommodating elements in such a way that satisfies certain criteria:

- e.g., Evidence and Strenght
- Behaves *as consistently as possible*.
- Behaves *as reliable as possible.*
- …

The *generic explanation* (inconsistency)

1. When having two scientific statements that contradict each other, scientists tend to assume that, at least, one of them is false (Laudan, 1977: 56).

1. If scientists are able to distinguish which of the conflicting propositions should be regarded as false, then they would be able to explain how they could satisfactorily work on seemingly false information.

1. However, most of the time, when confronted with an inconsistent set of information, scientists ignore, at least, which of the mutually contradictory statements should be regarded as false (cf. Bueno, 1997, 2006; Brown, 1999; Priest, 2002).

1. Once this ignorance is acknowledged, <u>if scientists have no better alternative to the inconsistent set of propositions</u>, the toleration of the contradiction becomes the only option at hand -such a tolerant attitude towards contradictions is often seen by scientists as a temporary resource.

Such a tolerant attitude towards contradictions is often seen by scientists as a **temporary resource**.

3. However, most of the time, when confronted with an inconsistent set of information, scientists ignore, at least, which of the mutually contradictory statements should be regarded as false (cf. Bueno, 1997, 2006; Brown, 1999; Priest, 2002).

The common agreement on this connection is that ignorance plays an important role in motivating scientists to tolerate certain contradictions, but also, that it is a constitutive element of the temporary character of such toleration.

If the toleration of defective information is a rational practice, philosophers/historians/sociologists of sc. should explain:

i. under which circumstances scientists would be rationally inclined to tolerate a D
ii. how they could preserve sensible reasoning when using D information.

Toleration of defective information

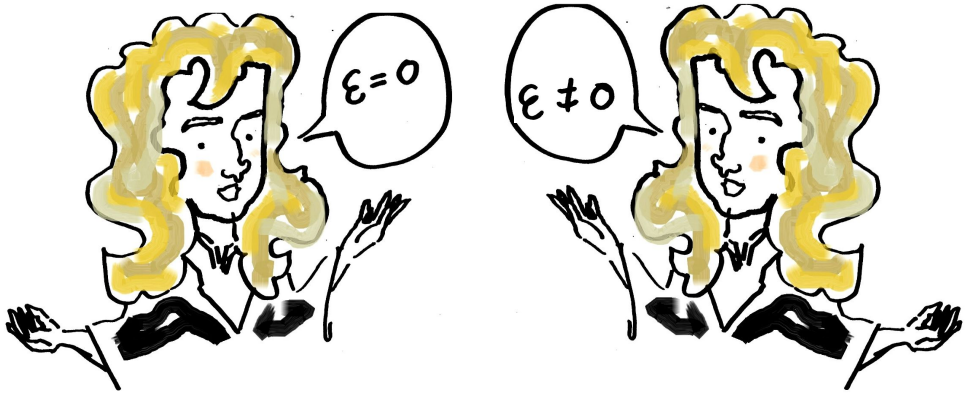
A phenomenon which takes place once agents identify a D in a relevant part of their reasoning and they are still:

- able to reason with or from this D-information to reach interesting conclusions.
- able to distinguish between the (inferential) products of their reasoning that are sensible given a particular context from those that are not (Meheus 2002, Carnielli and Coniglio 2016, Friend and Martínez-Ordaz forthcoming).

how do we explain this toleration?

HOW IS THIS POSSIBLE???

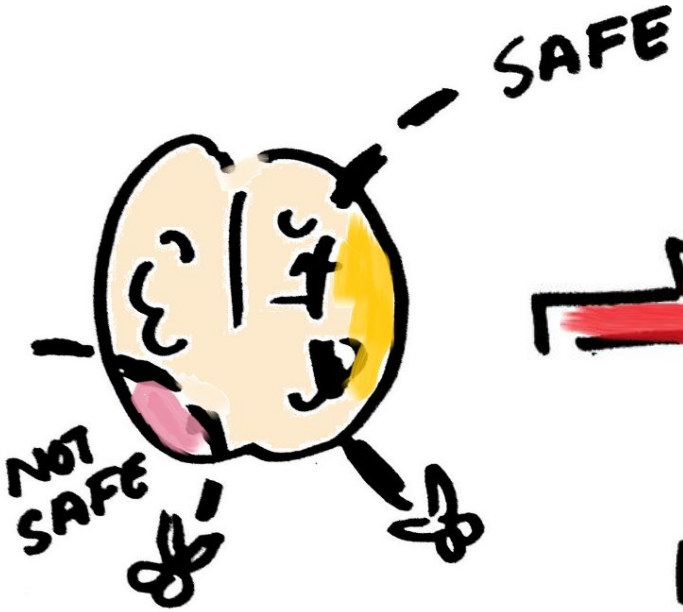
THIS IS ISAAC



THIS LOOKS LIKE A CONTRADICTION

HOW IS THIS POSSIBLE???

DOXASTIC WEAKENING



NEVER BELIEVE
A and ¬A

NO CHANGE OF LOGIC

HOW IS THIS POSSIBLE???

PARACONSISTENTISTS

CHANGE OF UNDERLYING LOGIC

HOW IS THIS POSSIBLE???

FRAGMENTATION

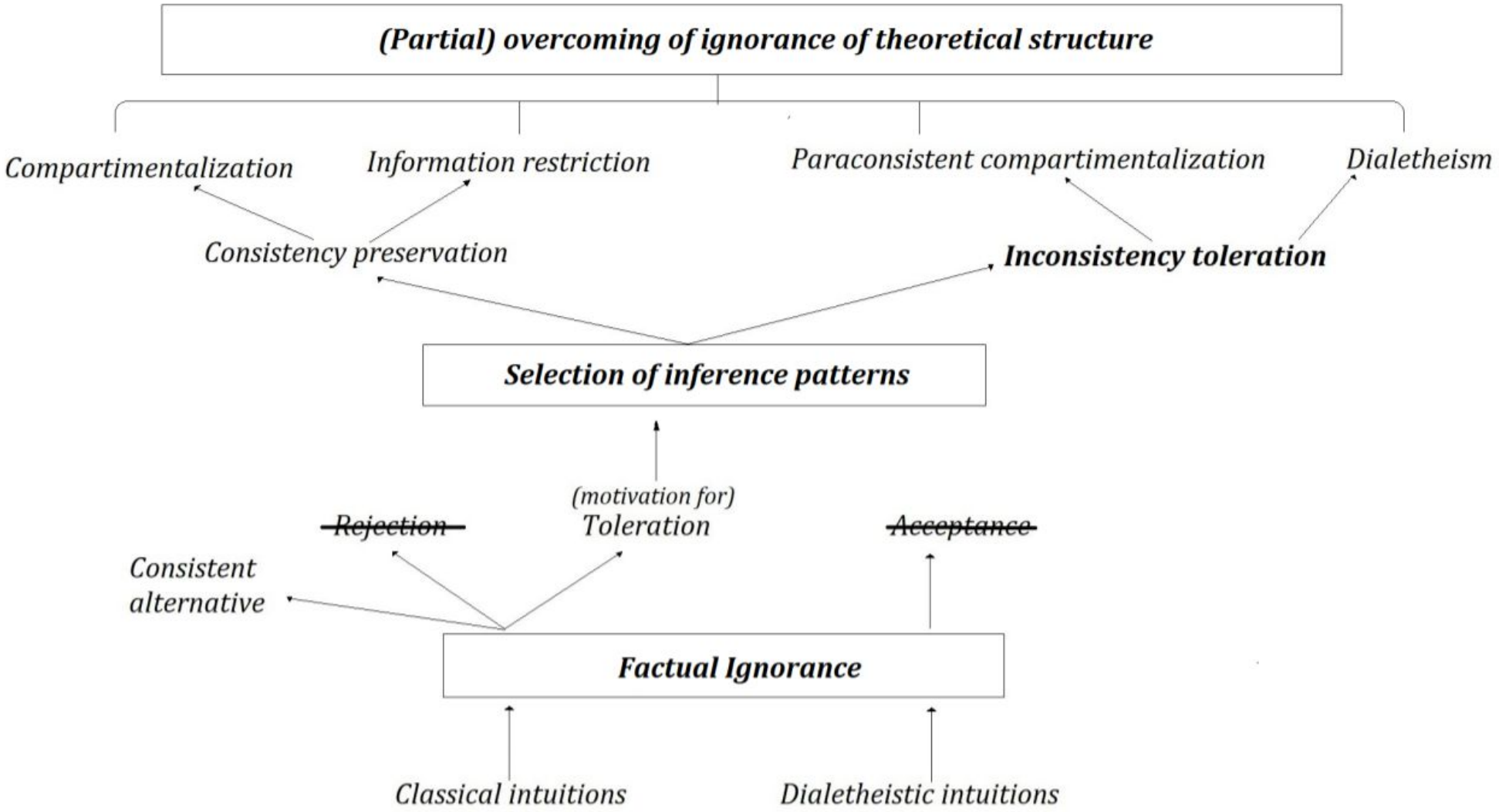
NEVER ALLOW FOR

$A \wedge \neg A$

HOW IS THIS POSSIBLE???

CHANGE OF UNDERLYING LOGIC

NO CHANGE OF LOGIC

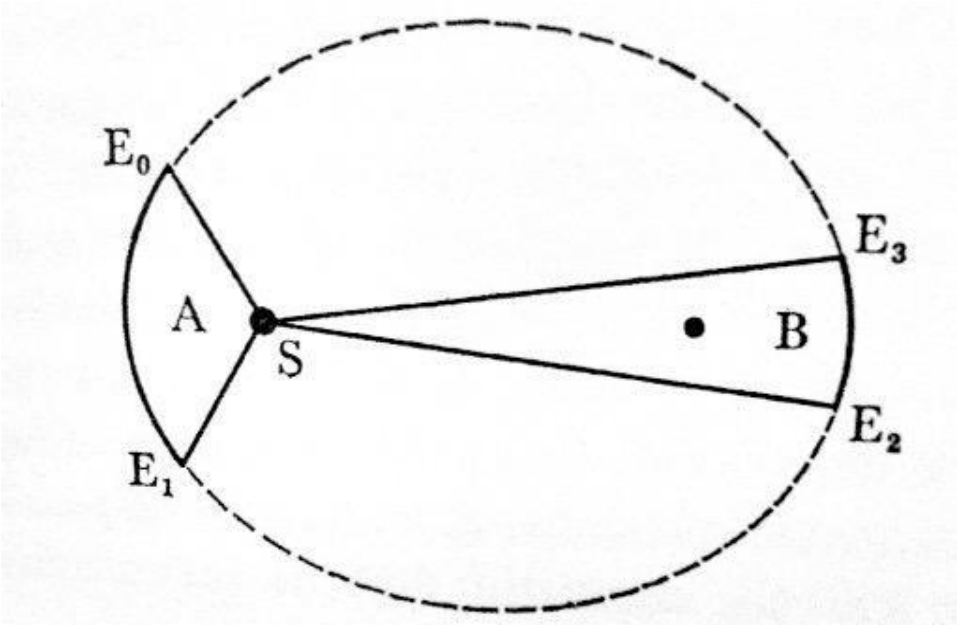

(Partial) overcoming of ignorance of theoretical structure
Compartimentalization
Information restriction
Paraconsistent compartimentalization
Dialetheism
Consistency preservation
Inconsistency toleration
Selection of inference patterns
(motivation for)
Toleration
Rejection
Acceptance
Consistent alternative
Factual Ignorance
Classical intuitions
Dialetheistic intuitions

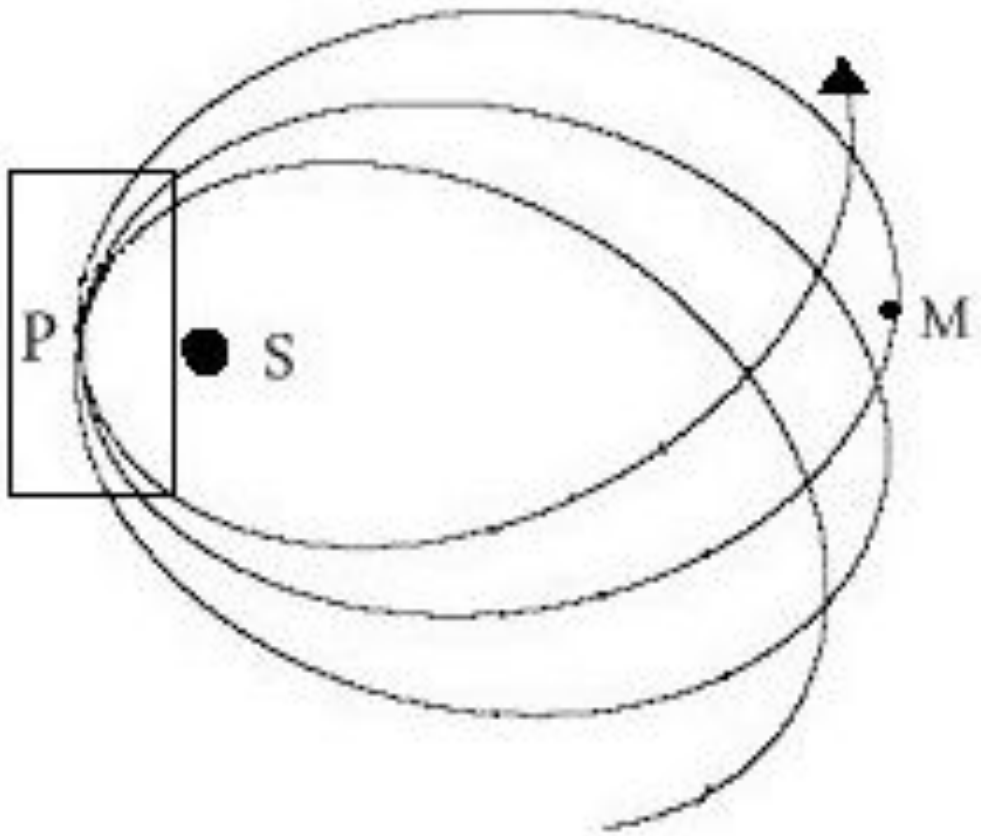
Case study 1

Theory-observation *contradiction**

- There is an empirical theory Γ, (where Γ has been well received by the scientific community) that has α as an observational consequence; and an experiment is made which leads to a report that ¬ α.

Mercury





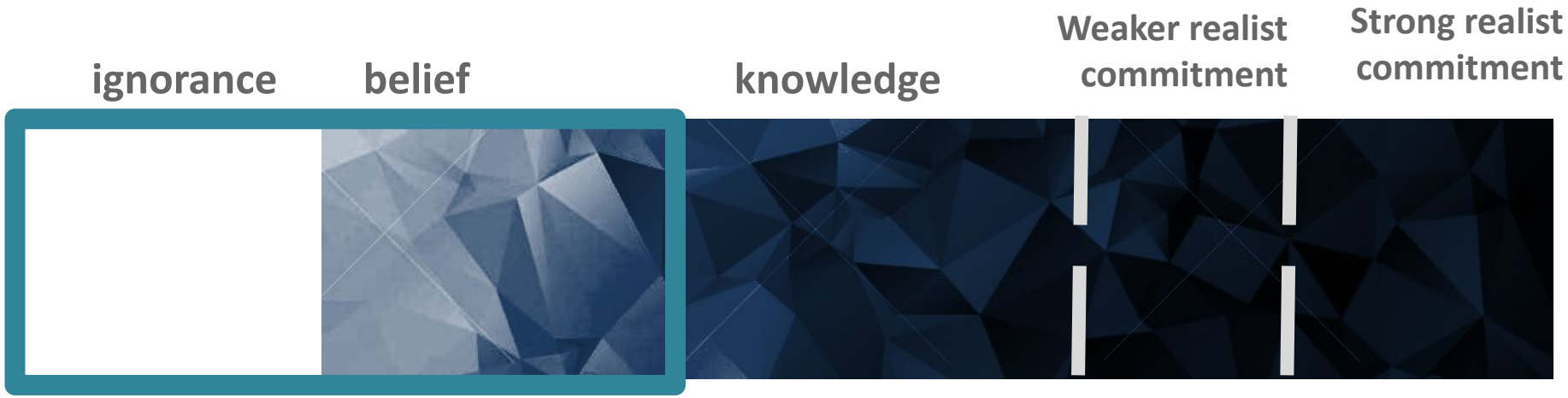
Plan session 2 (Phil sc)

0. Brief Recap

1. Scientific understanding
2. Understanding of defective data.
3. Case study 1 Standard Solar Model
4. Case study 2 Dictator game.

the epistemic landscape

the epistemic landscape



Ignorance

Ignorance of theoretical structure ?

Not knowing the value of the data (Cf. Floridi 2012).

Correlations □ ¬(causal exp) (Mayer-Sch□onberger and Cukier 2013: 14).

Epistemic opacity
-- products
-- processes

No understanding

Inconsistent information

Object of study

ignore the specifics of the domains of application

ignorance of causal links

Factual **ignorance**

Procedural **ignorance**

ignorance of causal links

Factual **ignorance**

Objectual **ignorance**

Explanatory Knowledge

Factual Knowledge

Procedural Knowledge

Objectual Knowledge

Understanding Preliminaries

- **Understanding:** “consist of knowledge about relations of dependence. When one understands something, one can make all kinds of correct inferences about it” (Ylikoski, 2013: 100).
  - It is often regarded as factive, this is, the content of understanding can only include true propositions that are known to be so.
  - Explanatory character of understanding

- The content of understanding:

Factivism

Quasi-factivism

Non-factivism

- *Do we achieve legitimate understanding of defective theories?*
  - Defective theories – Non-defective phenomena.
  - Defective phenomena –Defective theories.

  - Worries:
    - Theoretical (about the theories)
    - App (about the domain)

- “On the one hand, some philosophers emphasize that scientific understanding should ultimately be grounded in objective scientific explanations or knowledge of, for example, causal relations, where understanding consists in a ‘grasp’ of those explanations or causal relations (Grimm 2017; Khalifa 2017; Strevens 2013).

- On the other hand, there are philosophers who put the pragmatics of understanding center stage in their analysis. This typically leads to approaches that invoke the results of empirical study by, for example, psychologists, historians, or sociologists of science.”

De Regt, H. W. and C. Baumberger (2019): “What Is Scientific Understanding and How Can It Be Achieved?" in What Is Scientific Knowledge?: 66-81.

“CUP: A phenomenon P is understood scientifically if and only if there is an explanation of P that is based on an intelligible theory T and conforms to the basic epistemic values of empirical adequacy and internal consistency.

The key term in this criterion is ‘intelligible’: understanding of phenomena requires an intelligible theory, where intelligibility is defined as (De Regt 2017, p.40):

Intelligibility: the value that scientists attribute to the cluster of qualities of a theory T (in one or more of its representations) that facilitate the use of T.

This definition entails that intelligibility is not an intrinsic property of theories, but a context-dependent value: whether or not a theory is intelligible to scientists depends on, for example, their skills and their background knowledge.”

De Regt, H. W. and C. Baumberger (2019): “What Is Scientific Understanding and How Can It Be Achieved?" in What Is Scientific Knowledge?: 66-81.

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Ignorance of theoretical structure ---------- understanding

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Lacking knowledge of the (relevant) inference patterns that scientific theories allow for. When ignoring (the relevant parts of) the theoretical structure of a theory, scientists are not capable of grasping abstract causal connections between the propositions of their theory, they can neither identify the logical consequences of the propositions that they are working with nor can explain under which conditions the truth value of such propositions will be false. (Martínez-Ordaz 2020: 12)

Factual ignorance

Failure at assigning an alethic value to *x*

where is the defective information?

- **Felicitous falsehoods:**

  facilitate understanding by virtue of being the falsehoods they are: “[...] their divergence from truth or representational accuracy fosters their epistemic functioning” (Elgin 2017: 1).

  + empirical success.

- **Defective theories:**
  - Are theoretical constructs which operate on a defective basis –either assuming incompatible commitments, accepting defective procedures or characterizing defective entities (etc).
  - Can preserve and stress particular inference patterns between propositions—and it is expected that such patterns warrant the success of the theory in different contexts.

What are scientists doing when handling defective information?

The structuralist character of the view comes from granting that:

> What scientists really study are not any objects and their properties, but certain general inference relations or inference patterns (…) What exactly does speaking of ‘inference relations’ here involve; in particular, what are the relata: mere sentences (so that we are back to some kind of formalism?), propositions (leading us beyond formalism after all?), etc.? (Reck and Price 2000: pp. 347–348)

According to this view, one of the main tasks of scientific theories is to preserve and stress particular inference patterns between propositions—and it is expected that such patterns warrant the success of the theory in different context.

The peculiar case of serendipity

- “Serendipity is a category used to describe discoveries that occur at the intersection of chance and wisdom. To quote the word’s inventor, Horace Walpole, it describes “discoveries [made] by accidents and sagacity, of things [the observers]1 were not in quest of” (1754, quoted in Merton and Barber 2004, p. 2). “

(Copeland 2017)

The peculiar case of serendipity

- ABDUCTION, anomalous (lack of exp/ unpredicted), surprising (degree of accuracy)

- **Game-changing character** of serendipity and the **possibility of interpreting and explaining, *posthoc***, the discovery (Cf. Copeland 2015, Baumeister et al. 2010).

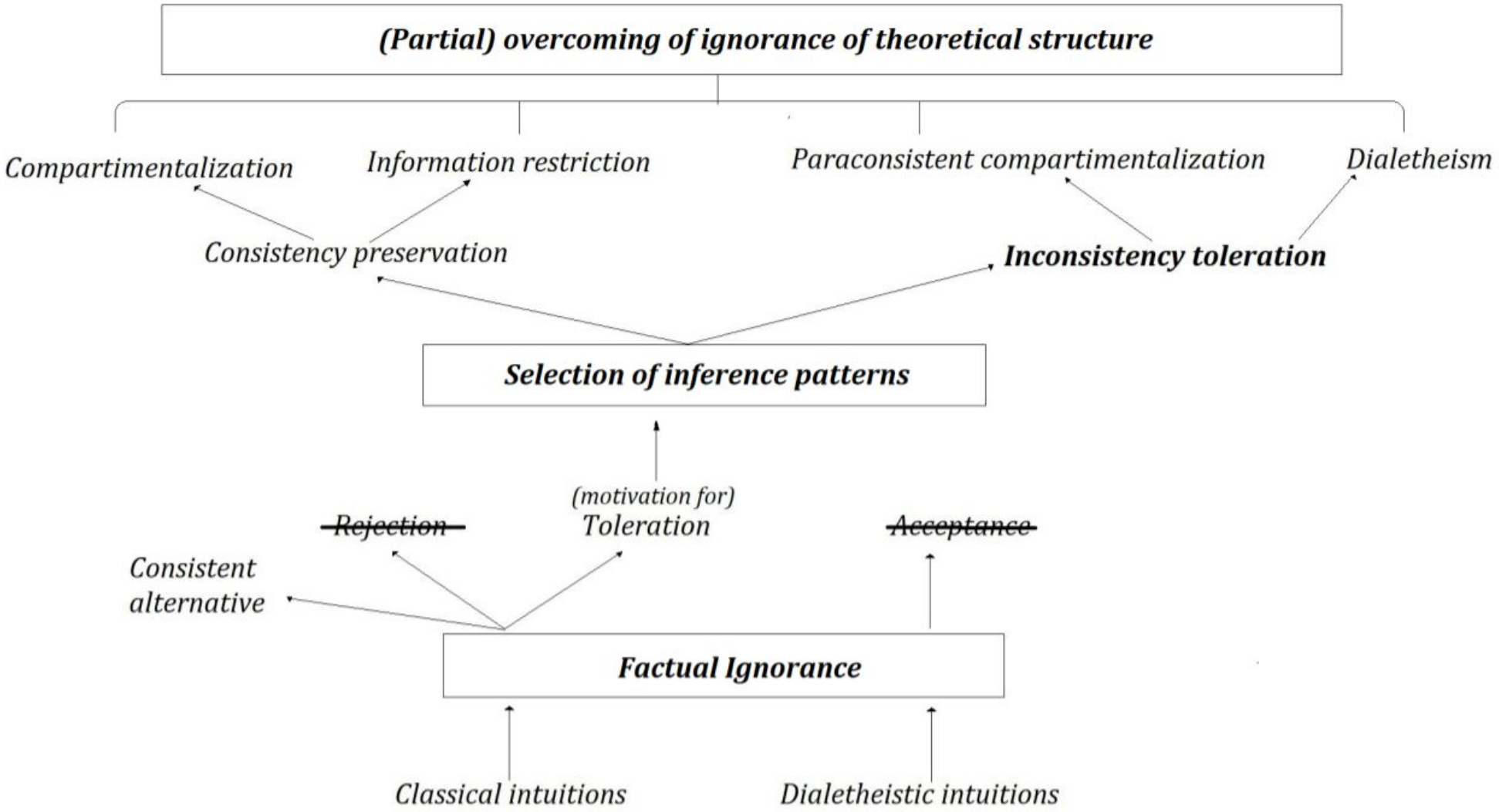
- Serendipity and ignorance(Cf. Magnani 2009; Arni 2016; Arni, Bertolotti and Magnani 2018).

intuition: we *survive* serendipity

Any examples?

- We understand a defective theory when we <u>recognize the theory's underlying inference pattern(s)</u> (…)
  - **Structure:** helps to connect the defective elements in such a way that they remain defective but non-dangerous (problematic).
  - **It** must be included as part of the content of understanding

Some understanding



Sketching the view

- When scientists master specific inference patterns within a particular domain, what they gain is a way to structure and follow successfully certain inferences in their day to-day practice; this is, not only that they can use inferential rules in an effective way but also that they can explain under which circumstances and why certain inferential rules are reliable in a domain of application of their theory.

- For this reason, when falsehoods (or any other defective elements) are included in the content of understanding, they must be joined by the inference patterns that allow them to remain well behaved.

The role of objective knowledge

- the type of understanding that can be gained through these practices is *modal understanding*

- One has some modal understanding of some phenomena if and only if one knows how to navigate some of the possibility space associated with the phenomena” (Le Bihan 2017: 112)

What are they getting?

At least

- Modal understanding
  - Which means that one can have a clear picture of the set of possible worlds that correspond to the causal structural connections that are relevant only with respect to some domain of the possibility space associated with the phenomena in question.

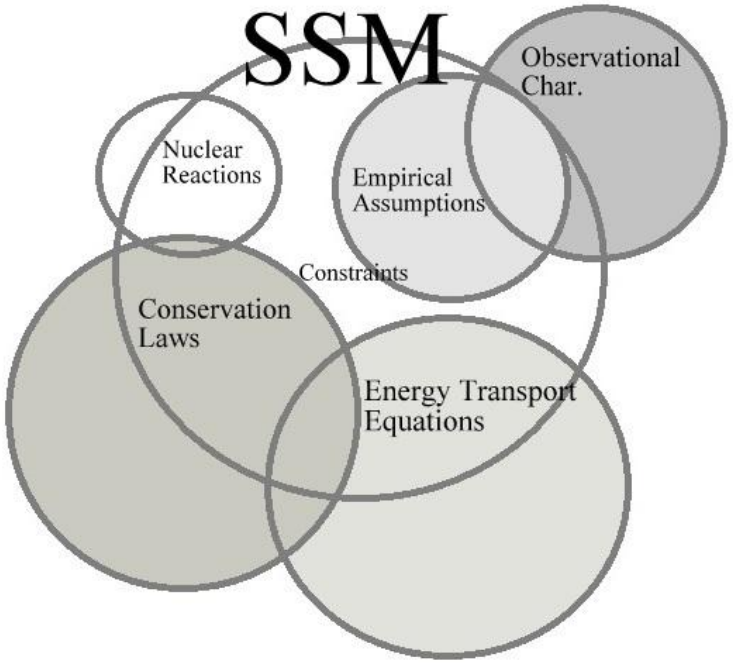
- But structures cannot be true.

- What is understood in cases of defective theories is, broadly speaking, that some structure is being posited of some objects in some domain for the purposes of saying explanatory things about them given the posited structure.

- But structures cannot be true/false.

case study 1: SSM

Standard Solar Model



1960-1970

Standard Solar Model (SSM)

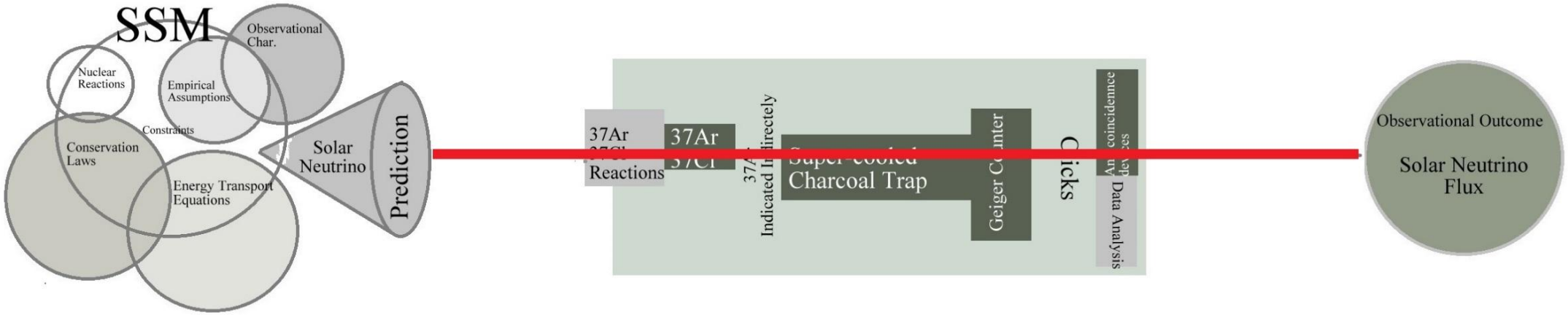
Measuring Solar Neutrino's flux

John Bahcall&Ray Davis' Experiment

Prediction _ Observational outcome:
+ 60% diff.

https://physicstoday.scitation.org/do/10.1063/PT.5.7049/full/

solar neutrinos



Observational Independence Criterion:

The set of propositions that underlie the design of instruments and methods used to evaluate the observational consequences of Γ, ideally, are achieved totally independently of the propositions belonging to the theory in question.

This condition stipulates that, as far as possible, **“something counts as observation more than as an inference when (…) the group of theories in which lies are not linked with the facts about the subject of study”** (Hacking, 1996; 214)

holism?

[T]he theoretical description of a system rarely takes place in isolation, but is instead correlated to the theoretical description of other systems in multiple ways (…) These correlations are of major consequence in the event of a discrepancy between theory and observation. If such a conflict arises, modifications need not necessarily start in the theoretical description of the system where the conflict was observed. Instead, correctional attempts may start with the theoretical treatment of some other system correlated to the first (Gähde 2002; 69, 70).

Summing up

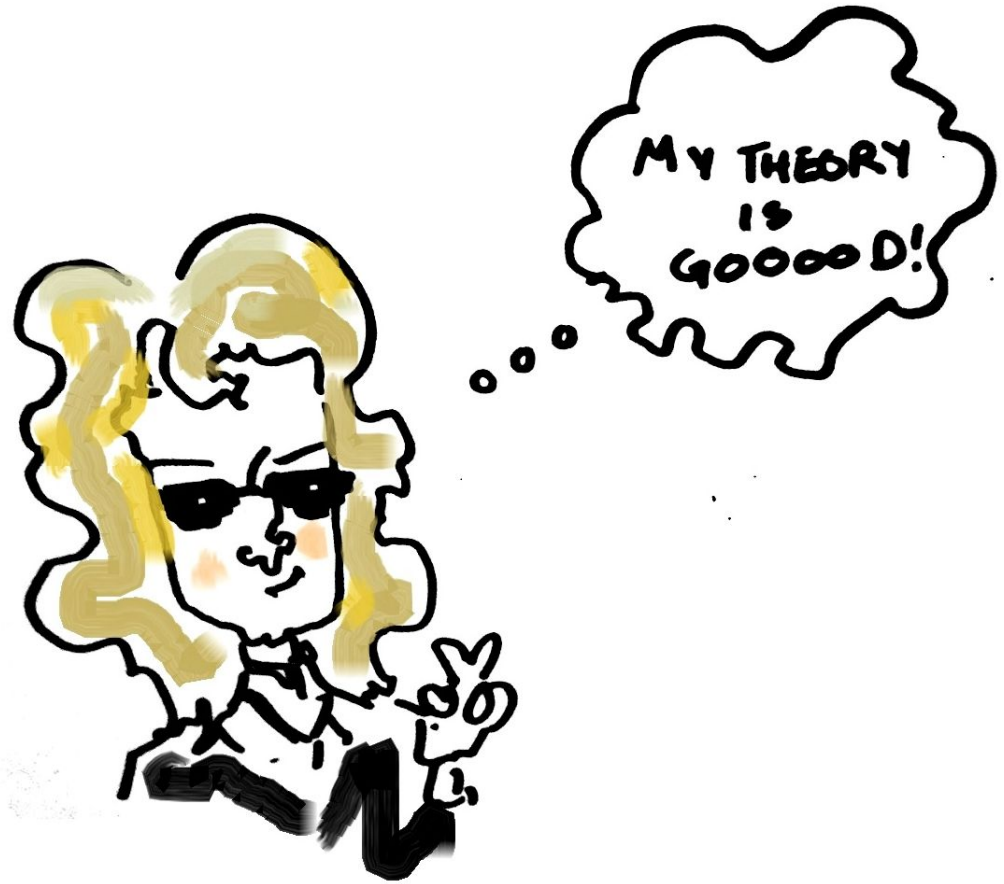
1. Defective ths. ≠ felicitous falsehoods
   - Structure

2. Ignorance of theoretical structure □ factive ignorance □ toleration of defects

3. When falsehoods (or any other defective elements) are included in the content of understanding, they must be joined by the inference patterns that allow them to remain well behaved.

further tasks

- Example
  - **Type of defect, why is it problematic**
  - **How it started? what were they ignoring?**
  - **How did they gain knowledge? which type of knowledge?**
  - **Did they get any further understanding of the phenomenon?**



the reliability of Defective information in the sciences

[Sessions 1 and 2]

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