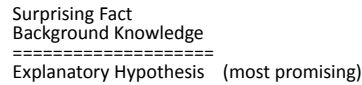


Abduction in Science and Metaphysics

(Gerhard Schurz, DCLPS, HHU Duesseldorf, Germany)

1. Abduction & IBS (Peirce, Harman) – the general pattern:



Two major families of abduction (Magnani 2009, Schurz 2008):

Selective abductions:

Search for explanations of empirical facts by *known* laws or theories.
E.g. explanation of footprint by someone walking here.

Frequently studied, well-known search strategies. (Flach/Kakas 2000, Aliseda 2006,...)

Creative abductions:

Search for explanations of empirical facts (regularities, dispositions) by new theories (about unobservable causes). Create new 'theoretical' concepts and laws connecting them.

Rarely studied, but needed for scientific theories and 'abductive' metaphysics. => **Topic of this talk**

Major challenge: Are there reasonable search strategies for creative abductions to theories? (debate in philosophy of science: Peirce, Popper, Hesse, ...)

Major problem: For every set of facts one can abductively 'infer' a perfect **post-facto** (pseudo) 'explanation.' – Two different kinds of pseudo-explanations:

1.) Logical pseudo-explanations, e.g. by "tacking by conjunction":
Evidence E is 'explained' by "E & X" where X = arbitrary, e.g. "creationism".

Tackings by conjunction
– **don't offer unification**, in the sense that a set of **elementary** empirical facts is reduced to a smaller set of **elementary** principles (Schurz & Lambert 1994).
– **don't produce genuine confirmation**, insofar E doesn't confirm here that content part of the hypothesis that logically transcends E (Schippers and Schurz 2020)

Similar problem in the probabilistic case: E is explained by "E was probable and X"

Lessons: (1) **Explanation is more than mere entailment or probability-increase.**
(2) **Notion of a content element** (content part/subject matter/verifier) is crucial for every notion of unification and genuine confirmation.
Cf. Friedman 1974, Schurz 1991, Gemes 1994, more recently: Yablo 2014, Fine 2017, Schurz/Weingartner 2010.

2.) Epistemic pseudo-explanations:

For every set of facts one can abductively 'infer' a perfect (and logically non-trivial) **post-facto** explanation, if one stipulates sufficiently many theoretical (hidden) variables.

Examples: Post-facto explanation of facts by God's wishes or by an intricate conspiracy theories.

Explanandum E: Opium has the disposition to make people sleepy (where this disposition is understood as a lawlike temporal regularity)

Abducted conjecture: Opium has a special power (a 'virtus dormitiva') by which it makes people sleepy. (Molière's example)

Explanandum E: Last week the Dow Jones index went up.

Abducted conjecture: God made this to support Biden.

Thus we have to exclude purely speculative abductions:

They postulate post facto for every observed fact or disposition a new hypothetical cause (that fits into one's wishful thinking'). A mere 'metaphysical duplication'.

Thesis:

Speculative abductions are without scientific/epistemic value, because:

- (1) **they do not provide unification**
- (2) they are **not potentially predictive** in the sense of being **independently testable by use-novel evidence** (Worrall 2006).

In contrast, scientific abductions possess these two virtues!

Question: do also metaphysical abductions possess these two virtues? (Paul 2012,...: yes; Ladyman 2012,...: no). **Do they at least possess the first virtue?**

2. More on Abductions in Science

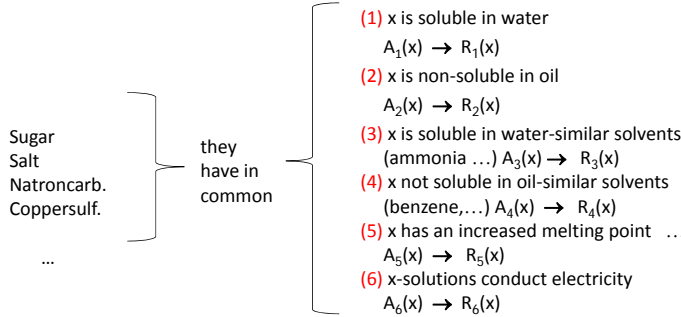
Most scientific abductions proceed as follows:
They infer from a set of **intercorrelated** (empirical) dispositions/regularities a **common** underlying **theoretical property/structure**, which may be conceived as their common cause (cf. Salmon 1984).

Note: I assume here that the causal base of a disposition is ontologically distinct from the disposition = regularity (against dispositional essentialism).

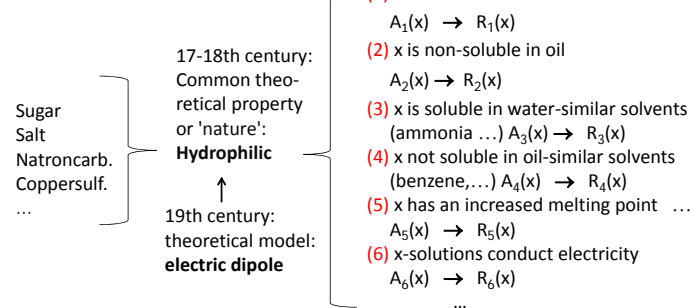
Examples:

- (1) Abduction of "force" in classical physics.
- (2) Abduction of evolutionary ancestors of species in biology.
- (3) -> **Abduction of chemical kind concepts: Solubility in water**

Kinds of Substances:



Kinds of substances S_i (m in number):



Unification: reduction of m-n empirical laws $\forall x(S_i x \rightarrow R_j x)$ to m+n theoretical laws $\forall x(S_i x \rightarrow Hx) + \forall x(Hx \rightarrow (A_j x \rightarrow R_j x))$

Moreover: Common 'cause' abductions are not post facto, but entail **novel predictions** by means of which they are **independently testable**.

Example: If a substance is soluble in water, then this indicates that it is hydrophylic and thus not soluble in oil.

Possible criticism: The search for unificatory explanations and novel predictions is merely **instrumentalistic**.

Question: What entitles us to assume that the theoretical 'common cause' is **true** in the realistic sense? -- Putnam's no miracles argument? Is problematic ...

Can we do better? Suggestion:

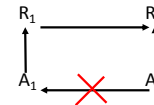
3. Justifying Abduction by Causality

By assuming a causality principle that is a consequence of **causal Markov condition**:

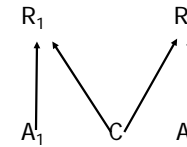
(C): If two properties or events are probabilistically dependent, then either one is a cause of the other, or - **if that is excluded** - both must be effects of a common cause (Spirtes, Glymour, Scheines 2000; Pearl 2009).

Dispositions are functional properties (regularities). They **cannot** be causes of other dispositions, given they have **independently realizable** antecedent conditions.

D_1 causes D_2 ? (e.g., solubility in water causes non-solubility in oil)
NO! violates independence of **A_1**



Common cause abduction:



Conclusion: (C) justifies a certain part of scientific realism (entity realism).

It entails that intercorrelations between (empirical) dispositions must be due to one (or several) common cause(s).

Note: Often one hidden cause is not enough to explain statistical correlations between observable variables → method of *factor analysis in statistics*.

Simplicity is implicitly inbuilt in common-cause abduction: it assume as few theoretical variables ('causes') as needed to explain the empirical correlations.

Warning: Not all abductions have straightforward causal interpretation. Sometimes *instrumentalistic* interpretations are preferable, e.g. in quantum mechanics.

4. Justifying Realism by Common Cause Abduction

Thesis: Justification of common sense realism works in the same way as abduction in science, though unconsciously (cf. Moser 1989, Vogel 2005, Niiniluoto 2018 ...):

There are strict correlations between our visual 2D perceptions of given objects from different positions – these are the internally given dispositions ("if I view from there, I have this-and-this visual impression").

Moreover: these visual dispositions are intercorrelated with position-dependent tactile perceptions.

The best or even only available explanation:

Is their explanation by a 3D object in 3D space that explains our position-dependent 2D images by the laws of perspectival projection of light rays.

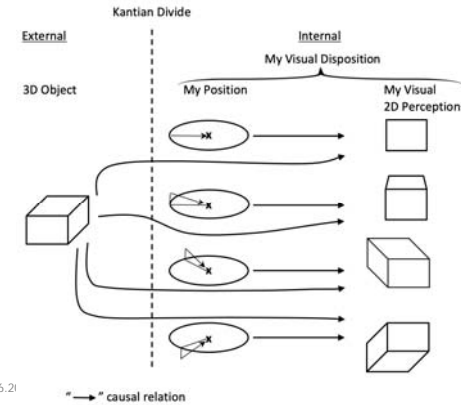
→ Is **predictively** extremely powerful (Clarke 2013: "Brain as a prediction machine"). Correspondingly, achieves powerful **unification**.

Positions at which I look:

{ Each of them has in common ... }

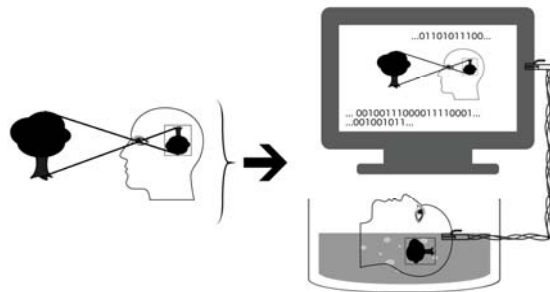
Correlated internal visual dispositions:

$A_1(x)$ (I look from here) $\rightarrow R_1(x)$ I have this 2D perception
 $A_2(x)$ (I look from there) $\rightarrow R_2(x)$ I have that 2D perception
 ...



Proposed solution if the brain-in-the-vat (BIV) problem:

All imaginable versions of BIV hypothesis assume a **isomorphic copy** of the ordinary realist explanation within the supercomputer; they just make additional (but explanatorily superfluous) assumptions. Thus the realist hypothesis is justified in the sense of structural realism.



Let's take a stock:

We have an abductive justification of the metaphysical principle of realism, based on the principle of common cause abduction.

Problem: But how can we justify the metaphysical principle of causality?

Is it "apriori" or transcendental (Kant)?

Or can we have an abductive justification of causality (considering "causality" as a theoretical concept)?

Yes, but on pain of avoiding circularity this justification must remain non-causal, solely based on unification and predictive power.

Thus: Abductions should not be restricted to causal ones (Williamson 2016).

5. Justifying Causality by (non-causal) Abduction

The challenge: Why do we need causality?

Thesis: Causality should not merely offer post-facto 'explanations' of empirical regularities, which postulate for each regularity a causal arrow.

Reason: This would be metaphysical duplication without empirical content.

Schurz and Gebharter (2016): **Cause-effect relations offer best (available) explanations of two (in)stability properties of correlations:**

1. screening-off and 2. linking-up

Explaining screening-off: Here a probabilistic dependence between two variables X, Y is screened off by a third variable Z: DEP(X,Y) but INDEP(X,Y|Z)

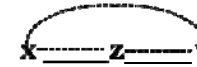
Examples:

1. Barometer reading (X), storm coming (Y), atmospheric pressure (Z)
2. Male (X), car accident (Y), car speed (Z)

Riddle: Why does the probabilistic X-Y dependency vanish, when we keep the value of Z constant, though arbitrary?

Best (available) explanation of screening-off: There exists a 'real' relation of direct 'causal' dependency between X and Z, and between Z and Y, which implies ("produces") the probabilistic X-Z and Z-Y dependency.

But there exists no direct causal X-Y dependency; the DEP(X,Y) is merely an indirect consequence of this - it is **mediated** by Z:

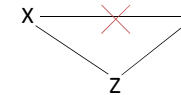


Variation of X-frequency can only lead to variation of Y-frequencies via variation of Z-frequency. *Thus:* if Z-values are kept constant, probabilistic X-Y-dependency breaks down.

Is this explanation of screening off the best one can give? Objections and replies:

Alternative explanation: Humean 'reduction' account or metaphysical duplication accounts: causal dependencies are 'duplications' of probabilistic dependencies.

Reply: Does not work. The explanation of screening-off is only possible because NOT every probabilistic dependency relies on a (direct) causal dependency.



Further alternative explanations ... involve complications (non-faithfulness)

Observation: For explaining screening-off, undirected 'causal' dependencies are sufficient. Direction is not yet needed, but is needed for

Explaining linking-up by directed causal dependencies:

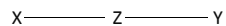
Here correlations have the opposite stability properties of screening off: INDEP(X,Y), but DEP(X,Y|Z) we call this "linking-up". (Berkson)

Example: position of sun (X), length of tower (Y), length of shadow (Z)

Sun position and length of tower uncorrelated, but if the shadow is long, then if the tower is small, sun position is deep.

Second riddle: Why should probabilistic dependency between X and Y, that didn't exist before, be generated, when conditionalizing on a third variable?

Answer again: Z mediates the probabilistic X-Y-dependency. **But the causal dependencies cannot be the same as before .**



because now we have opposite probabilistic stability effects.

→ Best/only (available) explanation: **causal dependencies are directed.**

Changes of value-distributions are propagated only along causal arrows.

Re-explaining screening-off (X-Z-Y) in terms of directed causal arrows:

Two direction-combinations can explain screening off:

1. Intermediate cause Z: $X \rightarrow Z \rightarrow Y$

DEP(X,Y) because a change of X-values causes a change of Z-values which in turn causes a change of Y-values. If Z-values fixed, this is impossible.

2. Common cause Z: $X \leftarrow Z \rightarrow Y$

DEP(X,Y) because a change of X-values is caused by a change of Z-values, which also causes changes of Y-values. If Z-values fixed, this is impossible

Linking up is explained by the remaining third possibility:

3. Common effect Z: $X \rightarrow Z \leftarrow Y$

INDEP(X,Y) because: a change of X-values causes a change of Z-values, which however does NOT lead to a change of Y-values, **because probability-changes are not propagated from effects to causes.**

DEP(X,Y|Z) is explained as in the sun-tower-shadow example.

Schurz & Gebharder 2016:

1. Generalization of these explanatory principles leads to **the theory of Causal Bayes Nets (TCBN)**, as expressed by the (global) Markov condition (Lauritzen et al. 1990) plus the condition of minimality.

2. TCBN's core axioms – Markov condition plus minimality – don't have empirical content, but if they are enriched with additional axioms (faithfulness, temporal directness, intervention conditions) they acquire **empirical content**.

7. The Justification of the Inference of (Creative) Abduction

Ultimate challenge: What justifies the abductive inference in the first place?

Schurz 2019: An instrumentalistic justification of abduction (in terms of its predictive success) is possible based on the results about the **optimality of meta-induction**.

A realistic justification requires a stronger principle of optimality, based preference relations between predictively equivalent alternative explanation, in terms of relations of isomorphic submodels (recall the BIV setting).

The end - thank you

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