Bayesianism, Unification and Coherence

On Bayesian accounts of scientific concepts

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I. A Bayesian Account of Unification

Wayne Myrvold's analysis of unification
(Myrvold 2003)

The basic problem of scientifc realism

- Every theory has empirically equivalent rivals

How do we choose theories?

- Theoretical virtues of a theory (simplicity, unification, explanatory power) might guide us to truth!
- The inference from empirical equivalence to arbitrary theory choice would then be blocked!
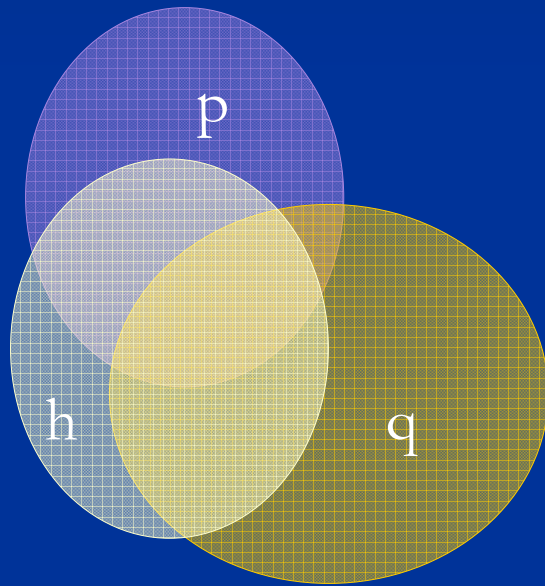
What is the value of unification?

Empirical virtue:

Unified theories get better evidential support

Theoretical virtue:

Unified theories are more beautiful, easier to handle,…

Can a mathematical explication
of unification support
scientific realism?

Myrvold's analysis of unification

Informational dependence
= probabilistic dependence

Probabilistic dependence
= mutual positive relevance
= mutual support

p and *q* are phenomena/sub-theories, *h* is the unifying hypothesis

Myrvold's analysis of unification

Unification = …

Reduction of informational independence
of the phenomena/sub-theories p and q by accepting the unifying hypothesis h

How does accepting h change the *mutual relevance* of p and q?

Mathematical analysis

Mutual relevance

$$I(p,q) := \log [P(q|p) / P(q)] = \log [P(p.q) / P(p)P(q)]$$

Mutual relevance conditional on h

$$I(p,q|h) := \log [P(q|h.p) / P(q|h)] = \log [P(p.q|h) / P(p|h)P(q|h)]$$

Degree of unification

$$U(p,q; h) := I(p,q|h) - I(p, q)$$
$$= \log [P(p.q|h) / P(p|h)P(q|h)] - \log [P(p.q) / P(p)P(q)]$$

Success stories

- **Application to paradigm cases:**

  Galilei's and Kepler's laws are relevant for each other in Newtonian mechanics, but quite independent of each other without Newtonian mechanics

- **Connection between evidential support and unification:**

$$r(h, p.q) = r(h, p) + r(h, q) + U(p, q; h)$$
$$l(h, p.q) = l(h, p) + l(h, q) + U(p, q; h) - U(p,q; \sim h)$$

(*r* and *l* are the log-ratio and log-likelihood-measures of confirmation)

Unifying power contributes to empirical support!

Success stories (II)

■ Whewell's theory of the strength of *consilient evidence* is explainable in terms of unification:

„The evidence in favour of our induction is of a much higher and forcible character when it enables us to explain and determine cases of a kind different from those which were contemplated in the formation of our hypothesis."
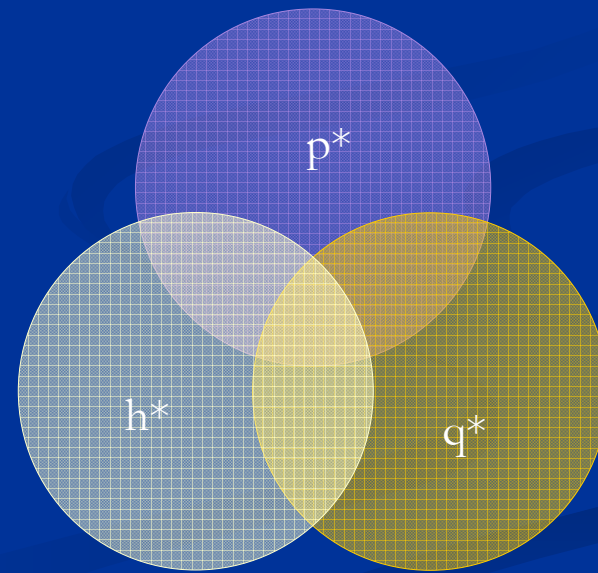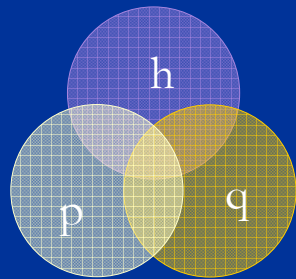
(Whewell 1847, *The Philosophy of the Inductive Sciences*)

II. Critique of Myrvold's proposal

Three objections against Myrvold's analysis
of unification

(1) The Scaling Objection

Compare the following two diagrams which are structurally identical (i.e. $P(p*|h*)=P(p|h)$ etc.):

(1) The scaling objection

One expects that $U(p^*,q^*; h^*) = U(p,q; h)$, due to the *structural identity* of both probability distributions.

Unification is supposed to be a *structural feature*.

However, in fact $U(p^*,q^*; h^*) > U(p,q; h)$!

The dependence on *absolute numbers* is an undesirable result, similar to the failure of mutual relevance to account for coherence (cf. Shogenji 1999)!

(2) Common causes

Let h be a common cause of p and q, i.e. $P(p.q|h) = P(q|h) \, P(q|h)$

$\Rightarrow I(p,q|\,h) = 0$

$\Rightarrow U(p,q;\,h) = - I(p,q) = \log P(p)P(q)/P(p.q)$

Interpretation:

Let h be a common cause of p and q.

$U > 0$ (i.e. h unifies p and q)…

if and only if p and q are (unconditionally) negatively dependent on each other!

(2) Common causes

This is utterly inadequate!

Two reasons against accepting the result:

➢ Unification is determined **independent of the properties of h**

➢ **Mutually supporting phenomena** might be unified further by a common cause

(3) Unification as Structural Change

The phenomena/sub-theories are often well-known and well-confirmed.

> **What does happen if we attach them a high degree of belief?**

Example: There was no reason to assign a prior belief significantly lower than 0.9 to Galilei's and Kepler's laws before Newtonian mechanics were established

> **Unification becomes almost impossible!**

(3) Unification as Structural Change

Moreover…

Mathematical and structural changes, simplifications, etc. might be the main characteristics of unification! (cf. Morrison 2000)

Rueger 2005 shows how the mathematical integration of two descriptions of a hydrodynamic system (i.e. micro-level and macro-level description) unifies the analysis of the system's properties!

Conclusions

Explication of Unification as mutual relevance…

A) fails mathematically (objection 1)

B) misdecribes common causes (objection 2)

C) neglects the mathematical-structural feature of unification (objection 3)

Myrvold's Bayesian analysis is inadequate!

III. Decoupling unification and coherence

The prospects of probabilistic reasoning in
the anaylsis of unification

Bayesianism is not the most promising approach to unification…

Lessons from the analogy to coherence:

➤ In both cases (coherence analysis and unification analysis) we assess dependence relations

➤ If even a mathematical explication of *coherence* as mutual support is problematic… (Shogenji 1999, Fitelson 2003)

    (Remember that coherence is more apt to an analysis in probabilistic terms than unification!)

What about another measure of mutual relevance?

Other measures of mutual relevance run into similar mathematical difficulties – compare the coherence discussion

Furthermore, *per definitionem*, none of the will meet the third, principal objection.

The double burden of mathematical and principal objections is hard to bear!

Unification as Coherence?

- Hartmann suggests to analyse unification in terms of coherence as confidence-boosting property of probability distributions (Hartmann 2006)
- Bayesian Networks grasp the relations between different theories and sub-theories
- Again, it is unclear how an analysis in terms of confidence-boosting can account for structural features of unification

Unification is too many-sided a notion to be suitable for a probabilistic analysis!

Literature (Selection)

- Myrvold 2003: A Bayesian Account of the Virtue of Unification, *Philosophy of Science* 70, 399-423.

- Bovens and Hartmann 2003: *Bayesian Epistemology*. Oxford University Press, Oxford.

- Fitelson 2003: A probabilistic theory of coherence. *Analysis* 63, 194-99.

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Thanks a lot for your attention!!!