Unification, Evaluation and Development of Theories

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Structure of Theories
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• Perception yields verified commitments (beliefs) in the existence e.g. particles and planets, and their movement
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• Metaphysical commitments function as the basis of explaining verified commitments, but are themselves unverified
Structure of Theories

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- Metaphysical commitments function as the basis of explaining verified commitments, but are themselves unverified.

Diagram:

- **ONTObvLOGY:** what exists according to a theory
- **METAphysicS** explains
- **VERIFIED** yields **PERCEPTIONS**
Structure of Theories

- Perception yields verified commitments (beliefs) in the existence e.g. particles and planets, and their movement.
- Metaphysical commitments function as the basis of explaining verified commitments, but are themselves unverified.

Everything posited by hypothesis is metaphysical: hypotheses of universal laws, unobservables, brute facts, primitives, axioms, unexplained explainers, hypothetical entities and principles.
Structure of Theories

1. Observations
2. Regularities
3. Laws
Structure of Theories

\[ r = \frac{a(1-e^2)}{1+e \cos \varphi} \]

\[ F = \frac{G m_1 m_2}{r^2} \]
Evaluation of Theories
Evaluation of Theories

• Evaluation of competing theories is about assessing the fitness of their predictions and explanations about the same phenomena, empirical data, perceptions, or verified commitments
Evaluation of Theories

• Of two theories that predict and explain the same phenomena, the most virtuous is the best
Evaluation of Theories

- Of two theories that predict and explain the same phenomena, the most virtuous is the best.
- What are the virtues and how can they be measured?
Evaluation of Theories

• Of two theories that predict and explain the same phenomena, the most virtuous is the best

• What are the virtues and how can they be measured?
  – Evidential: accuracy and depth
  – Unifying power: evidentiality/simplicity
  – Diachronic: development of unifying power over time
Evidentiality

- Can be measured by comparing a theory to empirical evidence
Evidentiality

• Can be measured by comparing a theory to empirical evidence

• Accuracy of predictions and causal depth of explanations
Evidentiality

• Can be measured by comparing a theory to empirical evidence

• Accuracy of predictions and causal depth of explanations

While in the case of an explanation, the final event is known to have happened, and its determining conditions have to be sought, the situation is reversed in the case of prediction: here, the initial conditions are given, and their “effect”—which in the typical case, has not yet taken place—is to be determined.

Evidentiality

- Can be measured by comparing a theory to empirical evidence
- Accuracy of predictions and causal depth of explanations
Accuracy of predictions
Accuracy of predictions

- Accuracy of predictions is the anchor of theory evaluation
  - Easy to measure
  - Most urgently needed: whenever there is a dire need, it is more important to know how nature behaves than why
  - Other virtues are subjugated to accuracy of predictions
Causal Depth of Explanations

1. Accuracy or the level of detail in which an explanation characterizes phenomena
2. Variability of circumstances where an explanation remains valid
3. Final test: prolificity of accurate predictions

Evidentiality is not enough

• The problem of underdetermination: we cannot select between two equally evidential theories based on their evidentiality only; therefore, we must evaluate other virtues too
Unifying Power

- Unifying power, the principle of Economy, parsimony, Ockham’s razor: of equally evidential theories, the simplest is the best

evidentiality/simplicity

E/M
Unifying Power

• A metaphysically simpler theory commits to a smaller number or quantity of hypothetical laws, entities, principles, primitives, brute facts, axioms, unexplained explainers

• A syntactically or mathematically simpler theory has a simpler formulation

evidentiality/simplicity

E/M
Unifying Power

Thomas Aquinas (1225-1274): “If a thing can be done adequately by means of one, it is superfluous to do it by means of several.”


William of Ockham (1287-1347): “It is vain to do with more what can be done with fewer.”


Isaac Newton (1642-1727): “We are to admit no more causes of natural things than such as are both true and sufficient.”

Principia, 3rd edition, bk.3

evidentiality/simplicity

E/M
Unifying Power

Eino Kaila (1935): “The smaller ... the number of its logically independent basic statements ... in comparison ... to the number of different kinds of facts that can be derived from it ... the greater is the relative simplicity of the theory.”


evidentiality/simplicity

E/M
Philip Kitcher’s (1981) *unification model*: scientific explaining is about unifying disparate phenomena or a diverse set of facts under a small number of basic principles or patterns.


evidentiality/simplicity

E/M
Development of Theories
Development of Theories

Development of unifying power

evidentiality/simplicity

E/M
Development of Theories

Development of unifying power
Unificatory vs. disunificatory development

evidentiality/simplicity
E/M
Development of Theories

Development of unifying power
Unificatory vs. disunificatory development
Positive vs. negative development
Success vs. regress

evidentiality/simplicity

E/M
Development of Theories

time goes forward; the amount of data to be explained grows
time goes forward; the amount of data to be explained grows; evidentiality grows
Development of Theories

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$E = M$
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Unificatory Development

- Newtonian mechanics
- Mendeleyev’s periodic table of elements

time goes forward; the amount of data to be explained grows; evidentiality grows
Disunificatory Development
Disunificatory Development

• Parametrisation: when a theory fails to give correct predictions of new data, it can be saved from falsification by accommodating the data by auxiliary parameters
Disunificatory Development

- Parametrisation: when a theory fails to give correct predictions of new data, it can be saved from falsification by accommodating the data by auxiliary parameters.

- When data is accommodated by the aid of additional metaphysics, the reality is so to speak be complemented by hypothetical entities in order to save the theory from falsification.
Disunificatory Development

• Parametrisation: when a theory fails to give correct predictions of new data, it can be saved from falsification by accommodating the data by auxiliary parameters

“no conclusive disproof of a theory can ever be produced; for it is always possible to say that the experimental results are not reliable, or that the discrepancies which are asserted to exist between the experimental results and the theory are only apparent and that they will disappear with the advance of our understanding.”

Disunificatory Development

time goes forward; the amount of data to be explained grows; evidentiality grows
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Disunificatory Development

-Standard cosmology (FLRW)

time goes forward; the amount of data to be explained grows; evidentiality grows
Disunificatory Development

Magnitude versus redshift: $K$-corrected Supernova observations

Disunificatory Development

Magnitude versus redshift: $K$-corrected Supernova observations

Disunificatory Development

The Nobel Prize in Physics 2011 was awarded "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae" with one half to Saul Perlmutter and the other half jointly to Brian P. Schmidt and Adam G. Riess.
From Newton to the Present
From Newton to the Present

1700->

unificatory development

1900->

disunificatory development

\[ E = \frac{E}{M} \]

\[ E = M \]
From Newton to the Present

- Newtonian mechanics was modified and complemented by the theory of relativity and quantum mechanics
  - SR 1905, GR 1915, GR-based cosmology 1917 onward: parametrisation/problems
  - QM 1920’s onward: no consensual ontological interpretation
- Standard model of particle physics 1960’s onward: parametrisation/problems
From Newton to the Present

normal science suffices

normal science is not enough
From Newton to the Present

“Failure of existing rules is the prelude to a search for new ones.”
The Challenge

1. To invent better theories
The Challenge

1. To invent better theories

2. Dogmatism:
   – Standard physics is highly parametrised and disunified
   – Normal science is not enough; new theories are needed
   – The scientific community effectively repels new theories, because they contradict the standard theories
   – Standard theories are taught to students without criticism, and the tradition goes on
'Normal' science, in Kuhn's sense, exists. It is the activity of the non-revolutionary, or more precisely, the not-too-critical professional: of the science student who accepts the ruling dogma of the day...in my view the 'normal' scientist, as Kuhn describes him, is a person one ought to be sorry for... He has been taught in a dogmatic spirit: he is a victim of indoctrination... I can only say that I see a very great danger in it and in the possibility of its becoming normal... a danger to science and, indeed, to our civilization.

Summary

• We need new theories that are more unified than the standard theories
• We must objectively evaluate new suggestions against standard theories
• To reach the optimal progress rate of science, we must accept better theories, even when they are different from standard theories
Thank you for your attention