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Social Science Research Methods

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Overview

- *Greek Philosophy of Science*
- *Medieval Philosophy of Science*
- *Saving the Appearances*
- Some Questions to Ponder
- The Seventeenth Century
- Newton's Axiomatic Method
- New Science and Scientific Method
- Inductivism
- Mathematical Positivism
- Conventionalism
- Falsifiability (1)
- Logical Reconstructionism
- Science as fact-based knowledge
- Induction
- Falsifiability (2)

Greek Philosophy of Science

- Aristotle's Inductive-Deductive Method
  - Observations
    - lead by induction to
  - Explanatory principles
    - which by deduction lead to
  - Statements about the observations
- Induction
  - By enumeration
  - By 'intuition'
- Deduction
  - Syllogism
- Genuine scientific knowledge has the status of necessary truth

Greek Philosophy of Science

- Extralogical requirements of scientific explanation
  - Premises must be true
  - Premises must be indemonstrable
  - Premises must be better known than the conclusion
  - Premises must be *causes* of the attribution in the conclusion
- Causes must be distinguished from accidental correlations
- A causal relation
  - Is true of every instance of the subject
  - Is true of the subject precisely
  - Is “essential” to the subject

Greek Philosophy of Science

- Aristotle's Four Causes (what makes something so)
  - A prerequisite for scientific explanation
  - Formal cause – "what is it to be . . ."
    - Nature, shape or design – general conditions
  - Efficient cause – "what produces . . . "
    - What brought it about (closest to our modern term)
  - Material cause – "what is it made from . . ."
    - Physical substance
  - Final cause – "what is it for . . ."
    - Purpose or intention (telos)

Greek Philosophy of Science

- Pythagorean philosophy
  - Mathematical harmony provides insight into the structure of reality
- "Saving the appearances"
  - Do mathematical relations that fit observed phenomena count as explanations?
  - Superimposing mathematical relations on phenomena "saves the appearance" but does not necessarily explain why the phenomena are as they are

Greek Philosophy of Science

- Deductive systematization (cf. Euclid, Archimedes)
  - The structure of a completed science should be a deductive system of statements
    - Axioms self-evidently true
    - Theorems deduced from axioms
    - Deductions make contact with reality

Atomism

- All that is real is the motion of atoms through the void
  - Entirely materialistic
    - No place for spiritual values, purposes, etc.
  - Ad hoc explanations
    - Unverifiable

Medieval Philosophy of Science

- Robert Grosseteste
  - Affirmed inductive-deductive pattern
  - Described as ‘resolution’ and ‘composition’
  - Hence subsequently known as the ‘Method of Resolution and Composition’
  - Developed inductive precursor to Mills’ ‘Joint Method of Agreement and Difference’
  - Method of Falsification
    - Used to eliminate all but one of competing explanations

Medieval Philosophy of Science

- Roger Bacon
  - Grosseteste's pupil
  - Emphasized accurate and extensive factual knowledge
  - 'First prerogative'
    - Principles induced by 'resolution' subjected to test of *further* experience
  - 'Second prerogative'
    - Data generated by active experimentation

Medieval Philosophy of Science

- Duns Scotus
  - Method of Agreement
    - ‘e’ *can be* the effect of a circumstance present in every instance
    - Establishes ‘aptitudinal unions’ only, not necessities
- William of Ockham
  - Method of Difference
    - A circumstance present when ‘e’ is present, and absent when not, *can be* the cause of ‘e’
  - Ockham’s Razor

Medieval Philosophy of Science

- Necessary Truth
  - Aristotle
    - First principles of science are necessary truths
  - Duns Scotus
    - Sense experience is sufficient to *recognize truth* of a first principle, but not to *prove* its necessity
    - A first principle is true in virtue of the meaning of its terms
    - Empirical generalizations are contingent
  - Nicholas of Autrecourt
    - Necessary truths satisfy the Principle of Non-Contradiction

Saving the Appearances

- Copernicus
  - A Pythagorean approach
    - The sun centered system was more than just a computational device
- Osiander
  - Took a contrary view of Copernicus' theory
- Galileo v. Cardinal Bellarmine
  - Despite disclaimers, Galileo took Copernicus' view
- Kepler
  - God as mathematician
  - Basically Pythagorean, but some suspect developments

Saving the Appearances

- Bode's Law

Planets:	Mercury	Venus	Earth	Mars	Asteroids	Jupiter	Saturn
Predicted:	4	7	10	16	28	52	100
Actual:	3.9	7.2	10	15.2	-	52	95.4

Saving the Appearances

- Bode's Law

Planets:	Mercury	Venus	Earth	Mars	Asteroids	Jupiter	Saturn	Uranus
Predicted:	4	7	10	16	28	52	100	196
Actual:	3.9	7.2	10	15.2	-	52	95.4	191.9

Confirmed? Real?

Saving the Appearances

- Bode's Law

Planets:	Mercury	Venus	Earth	Mars	Asteroids	Jupiter	Saturn	Uranus	Neptune
Predicted:	4	7	10	16	28	52	100	196	388
Actual:	3.9	7.2	10	15.2	-	52	95.4	191.9	300.7

Discredited?

Saving the Appearances

- Bode's Law

Planets:	Mercury	Venus	Earth	Mars	Asteroids	Jupiter	Saturn	Uranus	Neptune	Pluto
Predicted:	4	7	10	16	28	52	100	196	(388)	388
Actual:	3.9	7.2	10	15.2	-	52	95.4	191.9	(300.7)	395

Rehabilitated?

Some Questions to Ponder

- Is all research scientific?
  - The former President of the A.A.A. tells me so
    - Do you agree?
- Must non-scientific research be bad research?
- What makes some science “good” science?

Some Questions to Ponder

- "Stubbing my toe causes me pain"
  - What does this mean?
- "Time pressure causes auditors to make more mistaken decisions"
  - What does this mean?
  - How is it similar?
  - How is it different?

The Seventeenth Century

- Galileo
  - The book of nature is written in the language of mathematics
  - Physics restricted to statements about ‘primary qualities’
    - ‘Primary qualities’ are objective
    - ‘Secondary qualities’ are subjective
  - Excluded teleology
  - Anti-Aristotelian polemic not directed against inductive-deductive method, but against misapplication of it
  - Valued abstraction and idealization
  - Emphasized creative imagination in Method of Resolution
  - Applied Grosseteste and Bacon’s Method of Resolution
  - Ambivalent on experimental confirmation
  - Affirmed Archimedean ideal of Deductive Systematization

The Seventeenth Century

- Francis Bacon
  - Controversial role in the history of the philosophy of science
  - More successful as an expositor than as an innovator?
  - 'Novum Organum' claimed originality
    - Gradual, progressive inductions
    - Method of Exclusion (to eliminate accidental correlations)
    - 'Instances of the Fingerpost' to decide between competing explanations
  - Some criticisms of Aristotle misguided
  - Propagandist for organized scientific research
  - Moral imperative for man to recover domination over nature lost in the Fall

The Seventeenth Century

- Descartes
  - Inverted Bacon's procedure to proceed from most general claims
  - Committed to Archimedean ideal of deductive hierarchy
  - Like Galileo, distinguished 'primary' and 'secondary' qualities
  - Combined Archimedean, Pythagorean and atomist perspectives
  - Derived several important physical principles
  - Observation and experiment
    - Knowledge of conditions for events occurring
    - Suggest hypotheses specifying mechanisms consistent with fundamental laws
  - Recognized the value of experimental confirmation

Newton's Axiomatic Method

- Opposed theorizing about nature from metaphysical principles
- Method of Analysis and Synthesis
- Stressed experimental confirmation
- Emphasized the value of deducing consequences that go beyond the original inductive evidence
- Absolute Space and Absolute Time distinct from 'sensible measures'
- The bucket experiment

Newton's Axiomatic Method

- Formulation of an axiom system
- Specification of a procedures for correlating theorems of the axiom system with observations
- Confirmation of the deductive consequences of the empirically interpreted axiom system
- Sought to exclude 'hypotheses' from experimental philosophy
- For Newton
  - 'Theory' meant invariant relations among terms designating manifest qualities
  - 'Hypotheses' meant statements about terms designating 'occult qualities' for which no measuring procedures are known

Newton's Axiomatic Method

- Fruitful explanatory hypotheses
  - Admit no more causes than are sufficient to explain appearances
  - Assign the same causes to same effects
  - Qualities of bodies, which admit neither intensification or remittance of degrees, to be esteemed universal qualities (e.g., extension, hardness)
  - Propositions inferred by general induction 'nearly' true
- Scientific laws are contingent

New Science and Scientific Method

- John Locke
  - Like Newton, committed to atomism
  - Ignorance of atoms a contingent matter
  - Science consists of generalizations that are at best probable
  - Necessary connections do exist in nature
  - ‘Ideas’ are the effect of atoms in the real world

New Science and Scientific Method

- Gottfried Leibnitz
  - Successful practicing scientist
  - Two-way commerce between scientific theories and metaphysical principles
    - E.g., principle of continuity
  - Interpreted the universe using teleological considerations
  - Scientists reach only ‘moral certainty’
  - General metaphysical principles are necessary truths

New Science and Scientific Method

- David Hume
  - Extended and made consistent Locke's skeptical approach to the possibility of necessary knowledge of nature
  - All we can learn is constant conjunctions
    - All knowledge is subdivided into 'relations of idea' and 'matters of fact'
    - Knowledge of 'matters of fact' is given in and arises from sense impressions
    - Necessary knowledge of nature presupposes knowledge of the necessary connectedness of events

New Science and Scientific Method

- David Hume
  - Certain statements about the relations of ideas are necessary truths, established independently of any appeal to empirical evidence
  - Statements about matters of fact are never more than contingently true, and must be established by appeal to empirical evidence
  - Sense impressions are the sole knowledge of matters of fact

New Science and Scientific Method

- David Hume
  - If by ‘causal relation’ we mean both ‘constant conjunction’ and ‘necessary connection’ we can achieve no causal knowledge at all
  - Our impression of necessity is derived from custom and habit of mind
  - Eight Rules by which to judge of Causes and Effects

New Science and Scientific Method

- Immanuel Kant
  - Greatly disturbed by Hume's analysis of causation
  - Distinguished between the matter and the form of cognitive experience
  - Three stages in the cognitive organization of experience
    - Unstructured 'sensations' are organized with respect to Space and Time
    - Ordered 'perceptions' are related by means of concepts such as Unity, Substantiality, Causality and Contingency ('Categories of the Understanding')
    - 'Judgments of Experience' are organized into a single system of knowledge through 'Regulative Principles of Reason'

New Science and Scientific Method

- Immanuel Kant
  - With respect to theories, he valued predictive power and testability
  - Three ‘analogies of experience’ (necessary conditions for objective empirical knowledge)
    - E.g. “For every event there is some set of circumstances from which the event follows according to a rule”
  - We must systematize our knowledge *as if* nature were purposively organized
  - He defended the use of idealizations in scientific theories

Sidebar

- Rationalists
  - Descartes
  - Leibnitz
- Empiricists
  - Locke
  - Berkeley (Anti-realism, Idealism)
  - Hume (Skepticism)
- Transcendental Idealist
  - Kant
    - Categories
    - Synthetic a priori

New Science and Scientific Method

- John Herschel
  - Distinguished the ‘context of discovery’ from the ‘context of justification’
    - Context of discovery
      - Inductive schema
      - Formulation of hypotheses
    - Context of justification
      - Extension to extreme cases
      - Unexpected results
      - ‘Crucial experiments’

New Science and Scientific Method

- John Whewell
  - Sought to base a philosophy of science on a history of science
    - Facts are any pieces of knowledge
    - Ideas are rational principles that bind facts together
    - Pattern of scientific discovery
      - Collection and decomposition of facts, and clarification of concepts
      - ‘Colligation of facts’ – a particular conceptual pattern is superinduced on facts
      - Consolidation and extension

New Science and Scientific Method

- John Whewell
  - Consilience of Inductions
    - Successive incorporation of laws into theories
    - An Inductive Table in the form of an inverted pyramid
    - Inductive generalization in which observations and descriptive generalizations are subsumed under theories of increasing scope
  - Fundamental laws of nature have necessary status

New Science and Scientific Method

- Emile Myerson
  - Distinguished ‘empirical laws’ and ‘causal laws’
  - ‘Empirical laws’ allow prediction
  - ‘Causal laws’ permit understanding

New Science and Scientific Method

- Pierre Duhem
  - Scientific theories ‘represent’ but do not ‘explain’ experimental laws
  - A scientific theory consists of
    - An axiom system
    - Rules of correspondence which correlate some terms of the axiom system with experimentally determined magnitudes

New Science and Scientific Method

- Norman Campbell
  - Distinguished between an axiom system and its application to experience
  - A physical theory comprises
    - A hypothesis (a collection of statements the truths of which cannot be determined empirically)
    - A dictionary (relating the terms of the hypothesis to statements whose empirical truth can be determined)
    - In addition, a theory must be associated with an analogy to a system governed by previously established laws

New Science and Scientific Method

- Mary Hesse
  - The use of analogy in science claims two types of relations between the analogue and the system to be explained
    - Similarity relations between properties of the analogue and properties of the system to be explained
    - Causal relations which hold both for the analogue and for the system to be explained
  - ‘Formal analogies’ are distinguished from ‘material analogies’ by the absence of similarity relations independent of causal relations

New Science and Scientific Method

- Rom Harre
  - Argues for the centrality of models as being more consistent with the intuitions of scientists than, say, Duhem's approach:
    - Statements about a model
      - There exist molecules
      - Collisions are elastic
    - Empirical laws
      - PV/T is constant
    - Transformation rules
      - Pressure is caused by molecular impact
      - Temperature is mean kinetic energy of molecules

Inductivism

- John Stuart Mill
  - Context of Discovery
    - Method of Agreement
    - Method of Difference
    - Method of Concomitant Variation
    - Method of Residues
    - (Joint Method of Agreement and Difference)

    - Multiple causation greatly restricted applicability (especially in the case of composition of causes)

Inductivism

- John Stuart Mill
  - Context of Justification
    - Causal relations and accidental relations
      - Some invariable sequences are causal and others not
      - A casual relation is both invariable and unconditional
      - Ultimate laws of nature might be used to determine what is unconditional . . .
      - . . . But Mill failed to specify these
    - Mill's attempt to *justify* induction is circular

Inductivism

- William Jevons
  - Hypothetico-Deductive view
    - First, a hypothesis must be shown not to be inconsistent with other well-confirmed laws
    - Then, the consequences must be shown to agree with what is observed

Mathematical Positivism

- George Berkeley
  - "To be is to perceive or to be perceived"
  - Instrumentalist view - laws of mechanics are mere computational devices, with no reference to what occurs in nature
  - There is no distinction between 'primary' and 'secondary' qualities – because there are no 'primary' qualities
  - Absolute Space is meaningless

Mathematical Positivism

- Ernst Mach
  - Took a similar view to Berkeley
  - Principle of Economy
    - "the completest possible presentment of facts with the least possible expenditure of thought"
  - Sought to reconstitute Newtonian Mechanics from a phenomenalist point of view
    - Empirical generalizations
      - Contingent truths confirmed by experimental evidence
    - *A priori* definitions

Conventionalism

- Pierre Duhem
  - Disconfirmation
    - When the conclusion of a prediction is disconfirmed, then the *conjunction* of its premises is falsified
    - This is the conjunction of the laws and the conditions
    - To restore agreement with observations, the scientist is free to alter any one of the hypotheses that occur in the premises
    - In particular, any one hypothesis may be retained by modifying the others – this is to attribute to that hypothesis the status of a non-defeasible convention
    - cf. Bacon's 'Instances of the Fingerpost'

Conventionalism

- Henri Poincare
  - When a scientist holds a scientific law to be true independently of any appeal to experience, this is not because scientific laws are invested with necessity, but is an implicit decision to use the law as a convention that specifies the meaning of a concept
  - If a law is true *a priori*, it is because it has been stated in such a way that no empirical evidence can count against it

Falsifiability (1)

- Karl Popper
  - Proper empirical method is continually to expose a theory to the possibility of being falsified
  - Auxiliary hypotheses should only be added if they increase the degree of falsifiability
  - A test is a serious attempt at refutation
  - Acceptability of a law or theory is determined by the number, diversity and severity of tests it has passed
  - The history of science is a sequence of conjectures, refutations and revisions
  - A well corroborated theory has demonstrated fitness to survive – but this conveys no epistemological benefit: Popper's suggestion of a "whiff of inductivism" has been criticized

Logical Reconstructionism

- Philosophy of science emerged as a distinct academic discipline after the Second World War
- Norman Campbell hoped that a study of the foundations of empirical science would be as fruitful as the new development of axiomatic methods had been for mathematics
- The proper domain of the philosophy of science was recognized as the context of justification
- A hierarchy of levels was developed
  - Each level is an interpretation of the one below
  - Predictive power increases from base to apex
  - The ‘observational level’ is distinguished from the ‘theoretical’ level
  - Statements of the observational level provide a test-basis for statements of the theoretical level

Logical Reconstructionism

- Operationalism – Percy Bridgman
  - Scientific concepts must be linked to instrumental procedures that determine their values
  - This is what gives empirical significance to a scientific concept
  - If no operational definition can be specified, the concept is to be excluded from science
  - There are, however, some practical limitations
    - The need to ignore irrelevant factors
    - The need to accept some unanalyzed operations

Logical Reconstructionism

- The Deductive Pattern of Explanation
  - Carl Hempel and Paul Oppenheim
  - The deductive pattern of explanation of a phenomenon deduces the conclusion from General Laws and Statements of Antecedent Conditions (including boundary conditions and initial conditions)
  - Explanations based on statistical laws are not deductive; they can thus only provide (strong) inductive support

Logical Reconstructionism

- Nomic v. Accidental Generalizations
  - How can we tell when our explanations involve general laws, and when they involve only accidental generalizations?
  - General laws support counterfactual conditionals; accidental generalizations do not
  - According to Ernest Nagel, lawlike universals:
    - Not based on vacuous truths
    - Scope of predication not known to be closed
    - Not restricted in space or time
    - Often receive indirect support from evidence that directly supports other laws in the scientific system

Logical Reconstructionism

- Confirmation of Scientific Hypotheses
  - Hempel suggested that there are three phases in evaluating a scientific hypothesis
    - Accumulating observation reports
    - Ascertaining whether they confirm, disconfirm or are neutral towards the hypothesis
    - Deciding whether to accept, reject or suspend judgment on the hypothesis

Logical Reconstructionism

- Confirmation of Scientific Hypotheses
  - The Raven Paradox
    - Do black shoes and white gloves confirm that all ravens are black?
    - Hempel thinks so, and that our intuitions to the contrary are faulty
- Rudolf Carnap sought, instead, to formulate a theory of the *degree* of confirmation

Logical Reconstructionism

- The Structure of Scientific Theories
  - Post-war approaches were based on Campbell's distinction between an axiom system and its application to experience
  - What was needed was an adequate theory of confirmation
    - And no suitable theory was available

Logical Reconstructionism

- Theory Replacement
  - Emphasis on ‘growth by incorporation’
  - Ernest Nagel distinguished two types of reduction
    - Homogeneous reduction
      - A law is subsequently incorporated into a theory which utilizes substantially the same concepts (e.g., Galileo’s law reduced to Newtonian mechanics)
    - Deductive subsumption
    - A law is subsumed by a theory that lacks some of the concepts in which it is expressed (e.g., reduction of classical thermodynamics to statistical mechanics)
  - Nagel formulated conditions for reduction to succeed
    - Connectability
    - Derivability
    - Empirical support
    - Fertility

Interlude

- At this stage, we leave the historical development of scientific ideas behind until next week . . . and begin to look at Chalmer's review of some important idea themselves

Science as fact-based knowledge

- A widely held commonsense view
- Science is derived from the facts
  - Facts are given to careful unprejudiced observers via the senses
  - Facts are prior to and independent of theory
  - Facts constitute a firm and reliable foundation for scientific knowledge

Science as fact-based knowledge

- Seeing is believing
  - But visual experience is not determined solely by the object viewed
- Observable facts need to be expressed as statements
  - Statements do not enter the brain by means of the senses
- Why should facts precede theory?

Science as fact-based knowledge

- Observation statements are fallible
- Is observation private and passive or public and active
- Observable facts are objective but fallible
- We need not just facts, but relevant facts
- Experiment can be used to generate relevant facts

Science as fact-based knowledge

- Experimental results may be difficult to produce and require updating
- Circularity can arise in arguments that rely on experiment

Induction

- Deductive logic alone is not a source of new truths
- Induction is not logically valid
- General scientific laws invariably go beyond the finite amount of observable evidence that is available to support them, and thus cannot be proven

Induction

- What constitutes good inductive argument?
  - Many observations
  - Repeated under widely varied conditions
  - No counter-examples observed
  - This leads to a ‘Principle of Induction’
    - But:
      - How many instances?
      - What variations are superfluous?
      - ***No*** exceptions?

Induction

- How can knowledge of unobservables be incorporated by inductivists?
- How can exact laws be justified by inexact observations?
- The Problem of Induction – how is the Principle of Induction to be justified without circularity?
- Can we accept probability instead of truth?

Induction

- Immediate appeal derives from seeming to capture some commonly held intuitions about the special characteristics of scientific knowledge
  - Objectivity
    - Arising from observation, induction and deduction
  - Reliability
    - Follows from same things
- Still inductivism is at best in need of severe qualification and at worst thoroughly inadequate

Falsifiability (2)

- The Logical Positivists of the Vienna Circle advocated ‘verification’ as a test of scientific statements (as opposed to metaphysical statements devoid of meaning)
- Popper proposed ‘falsifiability’ instead
- It’s hard to verify a generalization: it’s relatively easy to falsify one
- Neither actual falsification nor practical falsifiability are required: it suffices for a theory to be falsifiable in principle

Falsifiability (2)

- More general statements or theories are more highly falsifiable (they have more potential falsifiers)
- Highly falsifiable theories should be preferred to less falsifiable ones, *provided they have not already been falsified*
- Theories should be clearly stated and precise

Falsifiability (2)

- Scientific progress
  - Problems
  - Falsifiable hypotheses
  - Rigorous testing
  - Elimination of failed theories and survival of others
  - New problems
- Significant advances come from bold, highly falsifiable conjectures

Falsifiability (2)

- Relative rather than absolute degrees of falsifiability
- Increasing falsifiability and ad hoc modifications (that introduce no additional falsifiability)
- Confirmation is still required
  - Significant advances may come from
    - Confirmation of bold conjectures
    - Falsification of cautious conjectures
- Boldness and novelty are relative to background knowledge

Falsifiability (2)

- Theory dependence of facts undermines inductivism
- Falsificationism recognizes that facts as well as theories are fallible
- Facts generating severe tests provide a stronger support than induction

Falsifiability (2)

- Some limitations
  - It is only the conjunction of observations, theories, and auxiliary conditions that must be rejected
    - Back to the Duhem-Quine thesis!
  - Historically, falsificationism is not how science has advanced
    - Consider, for example, the Copernican revolution
  - Other, non-scientific theories may also be falsifiable (e.g., astrology?)
    - But already falsified?
  - Popper's introduction of 'dogmatism' in response to these criticisms is problematic