# PHILOSOPHIES OF SCIENTIFIC TESTING

By John Bloore

Internet Encyclopdia of Philosophy, written by John Wttersten, http://www.iep.utm.edu/cr-ratio/#H7

# Carl Gustav Hempel (1905 – 1997)

- Known for Deductive-Nomological Model of scientific explanation (considered the standard model of scientific explanation during the 1950s and 60s)
  - A scientific explanation of a fact is a deduction of a statement
  - The premises are scientific laws and suitable initial conditions
  - If an explanation is true, the premises must be true
  - The explanation of a fact is reduced to a logical relationship between statements.
- This model is a common method used in Logical Positivism

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# Hempel – Logical Positivism

- Logical Positivism – only statements verifiable either logically, or empirically are cognitively meaningful.
- Confirming our scientific theories gives us added confidence to believe they are true
- Some factors that increase confidence of theory:
  - Repeatability, or additional tests conducted
  - Testing in different environments, different conditions
  - Scope of tests
  - Different people performing tests
  - Other scientific principles that back the given claim

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# What counts as evidence for a statement?

- Hempel's Raven Paradox:
  - X is a raven
  - X is black
  - A isn't a raven and isn't black
    - This also confirms that all ravens are black because we haven't found something that is a raven that isn't black
- This reveals a contradiction between inductive logic and intuition
  - Related to problem of induction and reveals a gap between inductive and deductive reasoning

A black raven

Non-black non-ravens

The raven paradox suggests that *both* of these images contribute evidence to the supposition that all ravens are black.

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# Problems with Hempel

- Weakness to deductive nomological model:
  - Allows causally irrelevant factors to be included
  - Doesn't place enough emphasis on the scope of relevant conditions
- Problems with inductive explanation (used in logical positivism):
  - Premises include statistical laws
    - Implies that scientific explanation of a fact can only give a high degree of probability, but is not a logical consequence
    - Form of the argument:

The relative frequency of $P$ with respect to $Q$ is $r$
The object $a$ belongs to $P$
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Thus, $a$ belongs to $Q$

The conclusion here is not certain, but it is based on a high degree of probability

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# Karl Popper (1902 – 1994)

- Rejects classical intuitivist views (like Hempel) and favors empirical falsification
  - A theory in the empirical sciences can never be proven, but can be falsified
    - Should heavily scrutinize scientific theories
  - If the outcome of an experiment contradicts the theory one should:
    - Refrain from ad hoc maneuvers to evade the contradiction
    - Further test it to make sure that the theory is indeed false

3- Internet Encyclopdia of Philosophy, written by John Wttersten, http://www.iep.utm.edu/cr-ratio/#H7

4- Stanford Encyclopdia of Philosophy - http://plato.stanford.edu/entries/popper/

# Karl Popper cont.

- Critical Rationalism (what Popper is most famous for)
  - Scientific theories are abstract in nature and can only be tested indirectly, by reference to their implications
  - Logically, no amount of positive outcomes in an experiment can confirm that a scientific theory is true
    - A single counterexample is logically sufficient to prove it is false though
  - A theory is only scientific if it is falsifiable

# Popper's response to problem of induction

- There is no way to logically prove that the sun will rise tomorrow, but we can formulate a theory that every day the sun will rise
  - If the sun doesn't rise, the theory will be falsified and will have to be replaced by a different one.
  - Until this happens, there is no need to reject the assumption that the theory is true
- Popper believes that the simplest theory (or one that is most easily falsifiable) that can explain the most known facts is the one that should be preferred to other possible theories

# Modern Testing Practices

- Test method – method for a test in science or engineering, such as a physical test, chemical test, statistical test.
  - This is a definitive procedure that produces a test result
- Types of tests
  - Qualitative, quantitative, categorical, personal observation, output of a precision measuring instrument
- A well written test method is important
  - Choosing the correct test method to measure the correct property or characteristic is also extremely important

Form and Style for ASTM standards - http://www.astm.org/COMMIT/Blue_Book.pdf

# ASTM Test Methods

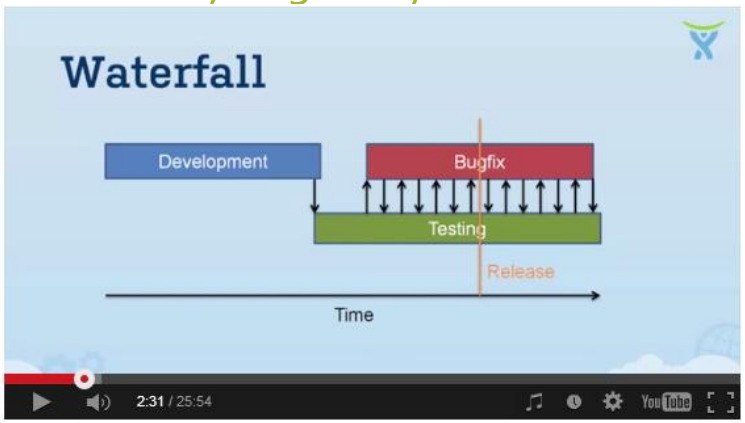
- Test Methods may include:
  - Descriptive title (mandatory)
  - Designation (mandatory)
  - Scope of which materials or articles may be evaluated (mandatory)
  - Reference to most recent test method validation
  - Person responsible for questions on the test method
  - Significance or importance of test method (mandatory)
  - Terminology and definitions to clarify meaning on test method
  - A list of materials or instruments needed to conduct the test
  - Safety precautions
  - Required calibrations
  - Environmental concerns
  - Samples procedures: how are they obtained, number of samples, sample size (mandatory)
  - Required environmental conditions (temperature, humidity, light, etc)
  - Preparations of samples for the test
  - Detailed procedure for conducting the test (mandatory)
  - Precision and bias of test (mandatory)
  - Interpretation of data and test method output

# ASTM Test Method Validation

- Accuracy and precision of experiment
- Repeatability and Reproducibility
- Range over which test method is considered accurate
- Curve fitting (especially for linearity)
- Robustness or how insensitive the experiment is to environment variables that we cannot control
- Measurement uncertainty
- Round Robin Testing – multiple independent people performing the test using the same method
- Validation practices relate to Hempel's confidence boosting criteria in affirming a scientific theory (according to Logical Positivism)

# Software Testing Practices

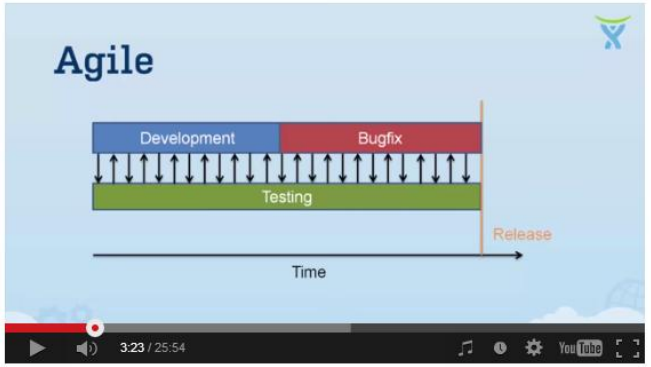
- Waterfall model - bad
  - Separates development and testing into two different steps
    - developers build a feature and then pass it along to the QA team for testing
    - QA often struggles to keep up because as the project grows, the testing grows exponentially
      - Project owners usually have to decide between delaying the release of a product, or skimp on testing (usually the case)
  - Often, QA testers are awarded for how many bugs they find
    - makes developers defensive
    - Should work together as




The Atlassian, written by Dan Radigan
https://www.atlassian.com/agile/testing

# Other Software Testing Practices

- Agile model – test and develop at the same time
- Treat bugs in new features and regressions in existing features differently
  - If a bug surfaces during development – take time to understand it, fix it, move on
  - If a regression appears (something that used to work but now breaks), it is likely to reappear
    - Create an automated test to protect against that regression in the future
- QA engineers should work with developers to give perspective to development where bugs are likely to appear

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# Conclusion

- Modern testing practices rely on theories developed by both Hempel and Popper
- We should take elements from both Philosophers when evaluating our theories or hypothesis
  - Important to use Hempel's thought process when evaluating how confident or reliable your scientific theory is
    - Seen in much of the ASTM test methods and test method validation practices
    - Used in every day intuition
  - Important to use Popper when testing to see if a product works
    - Seen often in software testing practices