Excerpts from An Enquiry Concerning Human Understanding (Hume) (1748)

David Hume (1711-1776)

Part I. Relations of Ideas and Matters of Fact

- In this part of the reading, Hume defines relations of ideas and matters of fact knowledge. According to Hume, there are two categories of objects of all human reasoning and inquiry: relations of ideas and matters of fact.
    - Relation of Ideas
        - Discoverable by the mere operation of thought
        - Forever retain certainty and evidence
        - Examples
            - Sciences of Geometry, Algebra, and Arithmetic
            - Three times five is equal to the half of thirty
    - Matter of Fact
        - Main subject of the reading
        - Contrary of every matter of fact is still possible
        - All reasonings concerning matter of fact is founded on the relation of <u>cause and effect</u>
            - Inference (beyond the evidence of our memory and senses) can only be made by this reasoning
            - Relations are either near or remote, direct or collateral
                - ex) heat and light are collateral effects of fire – these effects can be inferred from the other
            - How do we arrive at the knowledge of cause and effect?
                - Not a priori – entirely from experience
        - Examples
            - Billiard ball: communication of motion
            - Bread: proper nourishment for human but not lion or tiger

Part II. Inference

Main question: <u>What is the foundation of all conclusions from experience?</u>

- Experience → Relation of cause and effect → reasonings concerning matter of fact
    - Hume asks how do we go from experience to relation of cause and effect?
    - Answer that he gives:
        - "Even after we have experience of the operations of cause and effect, our conclusions from that experience are not founded on reasoning or any process of understanding"
        - Inference is not product of reasoning
            - Then how does the mind draw such inferences?

    - All arguments from experience are founded on the similarity
- Two kinds of reasoning
  - Demonstrative reasoning - relations of ideas
  - Moral reasoning - matter of fact and existence
- Improve by experience – learning

Discussion points

- When do matters of fact become relations of ideas?
  - For example, we can explain a lot of the cause and effect now with Physics, which, we do not assume to find contrary evidence
  - Can everything become relations of ideas?
- What are some examples of matters of fact problems in AI?
- What is inference? What is learning? If humans are also not reasoning, then how do we formulate our knowledge? How do we explain?
- Slow vs fast thinking? System 1 and system 2?
- Are humans also just relying on statistics of experiences?
- Are machines better at relations of ideas type of reasoning or matters of fact type of thought process?

The Logic of Scientific Discovery (Popper) (1959) (Chapter 1)

Here are my notes on the Popper Reading:

- Popper starts with a discussion of the *problem of induction*:
  - The empirical sciences tend to be based on inductive methods, where general conclusions are derived from singular statements derived from experience.
  - However, it is not obvious that we can infer general statements from singular statements
    - This ***problem of induction*** was first described by Hume
  - Popper argues that deriving a general *principle of induction* is generally a futile effort
- To avoid this, Popper makes a distinction between (1) the problem of conceiving a new idea and (2) the problem of examining/testing this new idea
  - Popper distances himself from the first problem but comments that we believe that it always involves some element of "intuition"
    - *"My view of the matter, for what it is worth, is that there is no such thing as a logical method of having new ideas, or a logical reconstruction of this process. My view may be expressed by saying that every discovery contains 'an irrational element, or a creative intuition'"*
  - He argues that the second problem can be tackled using "deductive" testing
    - Deriving individual statements from new ideas
- Popper then introduces the problem of demarcation: how to distinguish between scientific claims and logical/mathematical/meta-physical claims
  - Some criticism of **logical positivism**, which asserts that the solution to this problem is through inductive verification
    - This led to the exclusion of valid sciences where verification of theories is not possible
- He argues that ***experience*** should be the main driver in the problem of demarcation
- To avoid the problem of induction, he proposes **falsifiability** as a criterion of demarcation:
  - Asymmetry between verifiability and falsifiability: it takes "all the domain" to verify, a single example to falsify
    - We can go from the "truth" of singular statements to the "truth" of general statements
  - Popper argues that it is a solution to the **problem of induction:**
- He also touches on the problem of "empirical basis": how to derive individual statements from observations/experiments when these can be fallible
  - Argues that while this is a problem, it's a smaller problem compared to the problem of demarcation
- Finally Popper discusses the difference between scientific 'objectivity' and scientific 'subjectivity'
  - The objectivity of scientific statements comes from the fact that they are *inter-subjectively tested*
  - Argues for the importance of *reproducibility*
  - He also says that conviction/faith/beliefs can never be the basis for justification of a scientific theory
  - From this it follows that every statement in science, to be objective, must be testable
    - *"I refuse to accept the view that there are statements in science which we have, resignedly, to accept as true merely because it does not seem possible, for logical reasons, to test them.*

The Material Theory of Induction (Norton) (Prologue & Chapter 1)(2021)

- **The goal:** what makes inductive inferences in science valid (*licit*)?
- **Deduction:** posit axioms and perform inference according to a schema
    - Inference is valid by the definition of the schema
- **Induction:** Inferences from the particular to the general (*enumerative*, or *ampliative*)
- Observation/experience tell us how the world *is*, and we use them as **inductive support** for general propositions of **science**
- Two traditions in the philosophy of science literature
    - **Formal account:** Hypotheses generalize evidence, and we are able to deduce the evidence from the hypotheses
        - However, most evidence has many possible sets of hypotheses that support it, so we need a way to choose
        - Explanation has been offered as a criterion, but we have no good account of what an explanation is, beyond vague intuitions
    - **Bayesian account:** Assign a numerical value to the degree of support that evidence provides hypotheses, and calculate
        - Where do we get these numbers?
- The book (of which we read only the prologue and the first chapter) provides an alternative account, but first we will dive into issues with existing traditions
- *Consider a chemist who prepares a new salt of some metal and notes its particular crystalline form. It is routine for the chemist to report the form not only as the form of the particular sample but as the form of the salt generally.*
- Salt crystals take forms that are members of crystallographic systems
- *On the strength of just a few samples, the chemist is quite prepared to infer the crystal system of all samples of the salt:*
    - *This sample of salt A belongs to crystallographic system B.*
    - *Therefore, all samples of salt A belong to crystallographic system B.*
- Curie and Rutherford both studied the structure of radium chloride and barium chloride, and with only a few samples concluded that they share the same crystal structure
- Formal account
    - Deduction relies on abstract rules applying universally, regardless of context
    - Attempts to find similar rules for induction have failed
    - Can we explain this with a schema of the form
        - Some (few) *A*s are *B*.
        - Therefore, all *A*s are *B*.
    - *If the schema of enumerative induction is to function as a general logic, the restrictions on just what may be substituted for A and B have to be abstracted, regularized, and formalized, and then included in the schema. The problem is that the restrictions that must be added are so specific that one despairs of finding a general formulation.*
    - Is there something "natural" about which As and Bs are permissible? What makes them natural?
- Bayesian account
    - Hypothesis H: newly prepared salt belongs to some particular crystallographic system, Evidence E: samples

- $P(H|E)/P(\sim H|E) = (P(E|H)/P(E|\sim H))(P(H)/P(\sim H))$
- Since H says that all samples belong to the system, $P(E|H) = 1$
- How do judge $P(E|\sim H)$? What does it mean for the hypothesis to fail?
- If we let $P(E_i|\sim H) = q$, then $P(E|\sim H) = q^n$, and
    - $P(H|E)/P(\sim H|E) = (1/q^n)(P(H)/P(\sim H))$
    - This "washes out" the priors in the limit
- However
    - If you assume items of evidence are drawn independently, with $P(E_i) = s$, then $P(E) = s^n$, and $P(H|E) = (P(E|H)/P(E))P(H) = (1/s^n)P(H)$
    - The only way to ensure $P(H) \le s^n$ for arbitrary n is to set it to 0: prior skepticism
    - However, if you let evidence items depend on each other, P(E) either grows smaller asymptotically (due to the chain rule), or we have to impose that it approaches 1 as n grows: assuming the hypothesis
- This does not even consider that n is usually small. For small n, the "in the limit" arguments don't hold, and you are subject to magic numbers
- Most critically, Bayesian analysis is done only after the terms are defined. A lot of the inductive work has already been done by then, and results depend on the choice of these terms.

- **Material account**
    - Curie and Rutherford did not arrive at those claims out of the blue, they relied on a background knowledge of chemistry
    - Haüy posited that *all* crystals, however complicated their form may be, contain within them a primitive geometrical nucleus, which has an invariable form in each chemical species of crystallisable material
    - *For our purposes, the essential point is that if a chemist were to accept Haüy's theory, then one good sample of a crystalline substance would be sufficient to identify the crystallographic system to which all crystals of that substance belong.*
        - *Each crystalline substance has a single characteristic crystallographic form (Haüy's Principle).*
        - *The sample of salt A has crystallographic form B.*
        - *Therefore, (deductively) all samples of salt A have crystallographic form B.*
    - This looks like deductive inference from Haüy's Principle, until exceptions are found due to polymorphism. Now the inference becomes
        - ***Generally****, each crystalline substance has a single characteristic crystallographic form (Weakened Haüy's Principle).*
        - *The sample of salt A has crystallographic form B.*
        - *Therefore, (inductively) all samples of salt A have crystallographic form B.*
    - You cannot abstract "generally" into a schema because it does not have a universal meaning
    - *Inductive inferences are warranted by facts not by formal schema*.
        - It's not the form of the inference, but the facts that support it that warrant the inference

    - The schema used for inference is also subject to being consistent with evidence
- *All induction is local. It is contextual*.
    - Each inductive inference requires instantiating a specific schema based on the facts that support it
- *Inductive inference is generically variegated and imprecise*.
    - The “strength” of evidence is not quantifiable and universally comparable
    - Exceptions include background facts that authorize a mathematical calculus of inductive inference, like probabilistic facts
- *Inductive risk is assessed and controlled by factual investigation*.
    - *The warrant for an induction is a fact, and we assess and then control the inductive risk by exploring and developing that fact.*
- *Inductive inference is material at all levels*.
    - Inference is not formal when considered at a more abstract or a more fine-grained level