Induction

weekly_readings #week-13 #my-notes-755

> Taken from:
>
> 1. Class PPTs
> 2. The Reading: Inductive Reasoning.pdf

What is Induction

INDUCTION: Process of *drawing* **Generalizations** *from* **Specific observations**.

Although induction never provides definitive answers, we habitually use it for two primary reasons related to being human:

1. we categorize, infer causality, and reason by analogy in an attempt to explain and manage almost everything that happens around us
2. we reduce our uneasiness about an uncertain future by using past experiences to predict upcom ing events or outcomes

Knowledge about this topic provides us with insight into how **humans use limited data** to make rational inferences

Inductive Reasoning vs Deduction

Basis of Comparison	Inductive Reasoning	Deductive Reasoning
Typical Direction	Specific to general	General to specific
Type of Premise	Observations and patterns	General principles or facts
Common Type of Process	Often fast and automatic	Often slow and conscious
Conclusions	Go beyond the premises	Follow from the premises
Evaluation	Weak to strong arguments	Invalid/valid conclusions
Best Outcome	Highly likely to be true	Logically true and sound

EARLY VIEW AND ITS DRAWBACK

Bottom-up vs Top-down

- **Inductive reasoning is sometimes described as "bottom-up" logic** because specific observations are often used to draw general conclusions or principles that explain the evidence (Johnson-Laird, 2000)

    - *Example:*
        - "After observing that students who show up on time for my classes tend to perform better"
        - I might induce that "effective time management is a crucial component of academic success"
- In contrast, **deductive reasoning is sometimes described as "top-down" logic** to reason from general principles to derive specific conclusions (Johnson-Laird, 2000)
    - *Example:*
        - given the premises that "every first-year student at my small college must live on campus" and "Brenda is a first-year student"
        - I deduce that she lives on campus

Drawack-1 : Inductive reasoning can also lead to specific conclusions

- Recently found out that, the distinction between bottom-up and top-down processing is too simplistic because it does not apply to all cases of induction and deduction
- *Example:*
    - "It rained in Seattle yesterday. It rained in Seattle today. Will it rain in Seattle tomorrow?"
    - This scenario requires the solver to determine a probabilistic conclusion that is **specific** rather than general.

Drawback-2 : Same Problem can be solved in both way

- There are problems that some people solve inductively and others solve deductively, which means that **problem type cannot be used to determine which form of reasoning is being used**.
- *Example:*
    - Task of "buying a new car".
    - **Inductive Reasoning:** One individual might observe which models are commonly or rarely found in car repair shops before inducing which type of car seems to need the least amount of mechanical work.
    - **Deductive Reasoning:** Another individual might use the premises that "All cars made in Japan are good cars and Toyotas are made in Japan" to deduce that a Toyota is a good car that would be worth buying

CURRENT KEY DIFFERENCES BETWEEN INDUCTION AND DEDUCTION

Evidence that some problems can be solved either inductively or deductively has resulted in the process view of reasoning (Heit, 2007).

Instead of the traditional procedure of using type of problem to determine the form of reasoning being applied, the focus is on the mental processes that each individual employs

Dependence on External Knowledge of the World

- Deduction can be independent of external knowledge of the world or it may even contradict such knowledge.
  - *Example:*
    - “All dogs fly. Fido is a dog. Does Fido fly?” The correct answer ("Fido flies") is unsound and counterfactual but logically valid
- In contrast, inductive arguments are dependent on world knowledge rather than on formal rules of logic.

Continuum of Weak to Strong

- Inductive Arguments are evaluated on a continuum of Weak to Strong rather than the binary evaluation of Valid / Invalid
- **Weak Arguments:** have little support for the conclusions drawn from them to be likely true.
- **Strong Arguments:** based on relevant, substantial, and compelling evidence

Inductive Conclusion as a "Guess"

- **Inductive Conclusions** can be though of as "educated guesses" based on our current knowledge base
- **Deductive Conclusions** are not guesses. They are guranteed to be logically True

Speed of Reasoning

- Inductive Reasoning tends to happend **quickly** and **automatically**
- Deductive Reasoning happends more **slowly** and **deliberately (more consciously)**
- Some research has found **more activation in the brain’s left prefrontal cortex during induction**

SIMILARITIES BETWEEN INDUCTION AND DEDUCTION

- Both involve **evidence**, logic, **working memory**
- Both are central to **critical thinking**
- Both are used in Scientific method

> Everyone knows about Newton’s apple. Charles Darwin and his *Origin of Species* flashed complete in one second, and he spent the rest of his life backing it up; and the theory of relativity occurred to Einstein in the time it takes to clap your hands. This is the greatest mystery of the human mind–the inductive leap. Everything falls into place, irrelevancies relate, dissonance becomes harmony, and nonsense wears a crown of meaning. (p. 20)

- **Inductive reasoning** is used to form **hypotheses and theories** that advance scientific knowledge.
- Scientists then need to use **deductive reasoning** to **test** their hypotheses and theories on specific situations in order to verify their accuracy

Attributes of Inductive Reasoning

- We can never be 100% certain that our inductive conclusions are right.
- However, by keeping the following attributes in mind, we can reduce errors and biases, which increases the likelihood that our inductive arguments are strong

(1) Sample Size

- A large sample size helps **maximize information**, **reduces distortions in the evidence**, and makes the conclusions more likely to be correct.
  - *Example*
    - Observations: Every morning for the past 8 months, George drank a large glass of milk and thirty minutes later his stomach consistently started hurting.
    - Conclusion: George has lactose intolerance.
    - Observation: Natalie ate a peanut and then had trouble breathing.
    - Conclusion: Natalie has a peanut allergy
  - The first example has a stronger argument than the second because it is based on approximately 250 observations

Premise Monotonicty

- A higher number of inclusive premises results in a stronger inductive argument than a smaller number
  - *Example*,
    - *Nisbett and his colleagues (1983)* asked college students to estimate the percentage of obese male members of the Barratos tribe if they observed one obese tribesman, three obese tribesmen, or twenty of them. Results showed that participants were least likely to make strong inferences based on only one tribe member
  - This finding is known as **premise monotonicity**.

(2) Diverse Evidence

Inductive arguments are stronger if they present a range of converging evidence taken from different sources

Given that it would be time consuming and often impossible to collect every possible observation, people often use shortcuts or heuristics to reach inductive conclusions

Heuristics can result in quick and highly probable conclusions. Unfortunately, sometimes they can cause errors

Availability Heuristic

- We tend to use information that easily comes to mind, without also considering a significant number of cases that take longer to retrieve from memory
    - *Example:*
        - asked people to predict whether there are more words in the English language beginning with the letter R or more words with R as the third letter
        - 69% of their participants erroneously predicted that more words begin with R.
        - In other words, it is easier to generate words like “rutabaga”, “rat”, and “ridiculous” than it is to think of instances like “bard”, “certify”, and “dare.”
        - *According to Tversky and Kahneman, “to assess availability it is not necessary to perform the actual operations of retrieval or construction. It suffices to assess the ease with which these operations can be performed*
- The availability heuristic applies when people easily retrieve information from memory

Illusory Correlation

- *However, the availability heuristic can sometimes result in an **illusory correlation***
- **Illusory Correlation:** People believe a relationship exists when, in reality, it does not
    - *Example:*
        - while making prejudicial conclusions

Confirmation Bias - and its prevention

- Having a range of evidence,can also help prevent **confirmation bias**.
- **Confirmation Bias:** We have a tendency selectively to seek data that supports our hypotheses, while overlooking information that would invalidate them.
    - *Example:*
        - Suppose someone gave you the numbers 2, 4, and 6 that conform to a rule and asked you to discover the rule by generating sets of three numbers you think would fit.
        - When Peter Wason (1960) gave this task to adults, his nonobvious rule was “three numbers in increasing order of magnitude” but most participants assumed the rule was “increasing intervals of two”.
        - Thirty-one percent of the participants practiced what Wason refers to as **enumerative induction** (they did not try to disconform their hypothesis by terting odd numbers or descending numbers)

Eliminative Induction

- In science and in everyday life, it is essential to practice **eliminative induction** by seeking both confirming and disconfirming evidence before drawing conclusions.

Dynamic Availability of Knowledge

- The information in the premises of an inductive problem can have an immediate consequence for which knowledge we retrieve from memory in order to make our generalizations.
  - *Example:*
    - If we are told that "dogs have a recently discovered illness", we might infer that "cats will get it too" because we remember they often live in the same households.
    - However, if we discover that "dogs have a recently discovered gene", we would be more likely to conclude that "wolves also carry it" because we remember that the two species are genetically closely related.
- However, Knowledge availability is also influenced by Prior Experience:
  - *Example:*
    - **Novices** in a field are more likely to give *taxonomic* or *categorical* information
    - whereas, **Domain experts** tend to rely more on *causal*, *thematic* and *ecological* relationships

(3) Representative Observations

- The observations must fully represent the entire population of category of interest. (sample need to closely resemble the population)
  - *Example:*
    - Suppose you wanted to predict whether the citizens of California believe the legal drinking age should be lowered from age 21 to 18.
    - Polling undergraduates at several universities in California would probably tell you more about college students than it would about the beliefs of people in the entire state.
    - To draw potentially accurate conclusions about drinking attitudes in California, it would be important to obtain opinions from a representative cross-section of the people who live there.

Representativeness Heuristic

- When we're trying to assess how likely a certain event is, we often make our decision by assessing how similar it is to an existing mental prototype.
- *Example:*
  - Steve is very shy and withdrawn, invariably helpful, but with little interest in people, or in the world of reality"

- Is Steve more likely to be a farmer, librarian, salesman, airline pilot, or physician?
- Using the representativeness heuristic, people are likely to respond that Steve has the highest probability of being a librarian because he best fits how they view a typical librarian

Different Forms of Inductive Reasoning

1. Category-based Induction
   - Premise Typicality
   - Category Similarity (Premise-Conclusion similarity)
   - Premise Diversity
2. Causal Induction
3. Analogical Reasoning
4. Insight

(1) Category Based Induction

In this type of reasoning, if people are told that one or more members of a category have a certain property, they then determine whether other members of the category are likely to have the same property.

(1.1) Premise Typicality

Classical Study by Lance Rips

- Participants were told that a "particular species on an isolated island had a new contagious disease" and then asked to estimate the likelihood that other kinds of animals on the island would contract the disease.
- Results indicated that species' typicality had a large influence on individuals' inductive judgments, even when similarity was held constant.
- if one species (e.g., a robin) is highly representative of an inferred superordinate category (e.g., birds), individuals were more likely to generalize to other members (e.g., sparrows) than if the same information was given about an atypical member (e.g., canary)

Premise-Conclusion Assymetry

- An argument is stronger, if the **more typical member** of an inferred superordinate category is used in the **premise rather than in the conclusion**
  - *Example:*
    - It is more convincing to *project a property of lions onto bats* **than the other way around** because *lions are viewed as a better prototype of mammals than are bats*

(1.2) Category Similarity (Premise-conclusion Similarity)

- Perceived similarity between the premise category and the conclusion category strengthens inductive arguments and increases the likelihood that a novel property of one category will be generalized to another category.
  - *Example*
    - Individuals are more likely to generalize a property from "lions to wolves" than from "hippopotamuses to giraffes"

Similarity-coverage Model (Osherson, 1990)

- individuals automatically compute similarity and make inductive generalizations when
  1. There is a great deal of overlap between the features of the premise and conclusion categories, &
  2. There is substantial similarity between premise features and the inferred superordinate category (e.g., mammals) that is inclusive of the premises and conclusion.
- **SUCCESSES OF THIS MODEL:**
  1. This model is predictive of the **premise-conclusion similarity effect**
  2. It can also account for the **premise typicality results**
     (Typical premises have higher mean similarity to the inferred superordinate category than do atypical ones, which means that typicality provides better coverage)
  3. Also accounts for the **premise diversity effect**
     (less similar subordinate categories tend to provide more coverage of the inferred superordi nate category)

(1.3) Premise Diversity

- Other things being equal, arguments are stronger and conclusions are more probable if dissimilar subordinate categories are used as evidence.
  - *Example:*
    - if given the information that mice and lions share the same property, it is more likely that we will predict that elephants and other mammals also have the property
    - than if we are told that cougars and lions share the property

> **NOTE:**
>
> **Premise typicality**, **category similarity**, **premise diversity**, and **premise monotonicity** involve *taxonomic relationships* between *premises* and *conclusions*

(2) Causal Induction

Involves finding potential cause for observed effects

- Exert powerful effects, and **dominate other forms of induction** (and taxonomic effects: premise monotonicity, premise typicality, category similarity, premise diversity)
  - *Example-1:*
    - participants were given a novel category (e.g., Kehoe ants) and told characteristic features of its members (e.g., their blood has high amounts of iron sulfate).
    - Participants were then told about a novel property possessed by one of the category members (e.g., it has a venom that gives it a stinging bite)
    - Then asked to estimate the proportion of all category members that also possessed this new property.
    - In some conditions, participants were told that the new property was caused by a characteristic feature they had previously learned (e.g., the stinging bite is caused by the high amounts of iron sulfate in its blood).
    - When causal explanations were present, the standard effect of typicality was almost completely eliminated.
  - *Example-2:*
    - Consider which is a stronger inference?
    - (1) Deers contain the protein retinum, therefore, tigers contain the P.R.
    - (2) Lions contain the protein retinum, therefore, deers contain the P.R.

Theory of Causality - John Stuart Mill (1843)

- 5 methods (or canons) of causal analysis that focus on the observation of patterns.
  - 4/5 involve inductive reasoning
    - The first 3 help people practice Wason's (1960) notion of eliminative induction

1. **Method of Agreement:**

Member	Salad	Bread	Fish	Pie	Ill?
Mom	Yes	No	Yes	No	Yes
Dad	Yes	No	Yes	Yes	Yes
Brother	No	Yes	Yes	Yes	Yes
You	Yes	Yes	Yes	Yes	Yes

   - If all observed cases of a phenomenon have only one factor in common, then that factor is the likely cause of the phenomenon.
2. **Method of Disagreement:**

Member	Salad	Bread	Fish	Pie	Ill?
Mom	Yes	No	Yes	Yes	Yes
Dad	Yes	No	Yes	Yes	Yes
Brother	No	Yes	Yes	Yes	Yes
You	No	Yes	Yes	No	No

- If a phenomenon occurs in one observed case and not in another and there is only one circumstance that differs between the two cases, then this circumstance is the likely cause of the phenomenon

3. **Joint method of agreement and disagreement:**
   - combines the first two methods (Case: presence of a phenomena in some but not others)

Member	Salad	Bread	Fish	Pie	Ill?
Mom	Yes	No	Yes	No	Yes
Dad	Yes	No	Yes	Yes	Yes
Brother	No	Yes	Yes	Yes	No
You	No	No	Yes	Yes	No

   - *if there was anything your parents ate that you and your brother avoided. If there is, then this item would be a likely cause of their foodborne illness.*

4. **Method of Concomitant Variation:**
   - If there is a high correlation in the variations occurring for two different phenomena, one phenomenons is likely to be the cause of the other or a third unknown variable might be causing the variation in both.
   - *Example:*
     - Suppose you did not eat berry pie at the buffet, your mom had half a piece, your brother had a whole one, and your dad ate five pieces.
     - You feel fine later that night, your mom feels a bit queasy, your brother is moderately sick, and your poor dad needs to be rushed to the hospital.
     - A highly probable conclusion to infer from this evidence is that "**suffering from the effect (i.e., food poisoning) is proportional to the cause (i.e., the amount of pie consumed)**"

What sources of Info are used during causal inferences?

- Miriam Schustack and Robert Sternberg (1981)
- Participants were given information about various cosmetic companies, including the facts that
  - (a) a company did or did not have a major product under suspicion as a carcinogen, and
  - (b) the company's stock had or had not drastically dropped.
- Participants were then asked to infer the probability that **some other cosmetic company** would have its **stock values drop drastically** if it had a **major product under suspicion as a carcinogen**.
- Overall results indicated that people confirm a causal relationship in one of two ways.
  1. (related to Mill's **method of agreement**) based on evidence of the joint presence of the hypothesized cause (e.g., suspicion of a carcinogen) and effect (e.g., declining stock values).
  2. (related to Mill's **method of disagreement**) based on evidence of the joint absence of the hypothesized cause and effect.
- Overall results also indicated that people disconfirm causality in one of two ways.

1. Presence of the hypothesized cause but the absence of the outcome , and
2. Absence of the cause, yet the outcome still occurs

(3) Analogical Reasoning

- Reasoning by comparing two domains of knowledge in order to infer a quality they have in common
  - The First Domain - more familiar, serves as a source/base
  - The Second Domain - more novel/abstract
- Used both in image and verbal form

Example-1:

- Learning the structure of atom (yet unknown) using the analogy of the solar system (known)

Example-2: (verbal problem)

- `Lawer : trial :: Surgeon : ?`
- (a) a stethoscope, (b) medical school, (c) an operation, (d) patients.

Steps in Analogical Reasoning

Robert Sternberg (1997)

1. **Encoding:** recalling mental rep. of "lawyer" and "trial" base terms
2. **Inferring:** guessing relations between the base terms (lawyer "engages" in trial)
3. **Mapping:** Encoding target term ("surgeon") and identifying parallels between it and the base term ("lawyer")
4. **Applying the Relation:** Relation b/w base terms is extended to target term ("lawyer does trial", "surgeon does ...?")
5. **Response:** Preparing a response ("operation")

*Findings - Robert Sternberg (1997)

- participants spent quite a bit more time on **encoding** and **preparation-response**.
- preparation-response component was most highly correlated with standardized tests of reasoning.

Meta Components involved - that influence the above steps (components) - Robert Sternberg (1997)

- Some individuals do not form a connection between the first and second halves of an analogy because they do not select the lower-level component of mapping.
- Other individuals might not select the best strategy for combining lower-level components

Relational Similarity - Robert Sternberg (1997)

- For analogical reasoning to work, the basis constaint is Relational (or structural similarity)
- Elements of the analogy need to be linked by a relation they have in common.
- **Surface similarity is not required** (eg- *Computer and Humans are not physicallly similar, but relationaly similar in terms of information processing*)

Analogical Reasoning is not always done consciously

- Blanchette and Dunbar (2002)
- Had participants read descriptions of a target topic (e.g., legalization of marijuana) and then read shorter information about a potential analogical base (e.g., prohibition).
- Afterwards, when participants were given a recognition test, they erroneously believed that their analogical inferences were concrete facts actually presented in the target description

(4) Insight

Sudden insight into the solution of a seemingly impenetrable problem is another form of inductive reasoning (Goswani, 2011) or what Steinbeck (1954) referred to as the **inductive leap**

In contrast, an **analytic process** involves consciously and systematically evaluating the problem, using strategic thinking and deduction.

Example:

- Janet Metcalfe (1986a, 1986b; Metcalfe & Weibe, 1987) and Davidson (1995)
- Found that, "incremental increases in feelings of confidence (or warmth) that one is nearing a solution":
  - **negatively predict correct solution** of **insight problems**
  - **positively predict correct solution** of **deductive reasoning problems**.

An important source of insight involves cognitive restructuring of a problem's components, which can occur multiple times as an individual moves from general to specific mental representations of a problem

Insight is process rather than problem oriented

Example:

- One individual may solve a problem by having an inductive leap;
- While, another person may solve the same problem incrementally and consciously

The Gestalt psychologists believed that people's inability to restructure a problem's components and produce an insightful solution is often due to their fixation on past

experience and associations.

Example:

- Karl Duncker (1945)
- Gave individuals three small cardboard boxes, candles, matches, and thumbtacks. The participants' task was to mount a candle vertically on a screen so that it could be used as a reading light.
- The solution is to light a candle, melt wax onto the top of a box, stick the candle into the wax, and tack the box to the screen.
- Participants who were given **boxes filled** with tacks, matches, and candles had much more difficulty solving the problem than did those who received the same supplies outside of the boxes.
- According to Duncker, seeing a box serve the typical function of a container made it difficult for many individuals also to view the box as a structural support. This phenomenon became known as **FUNCTIONAL FIXEDNESS**.