Heuristics in Reasoning

1. Prescriptive vs. Descriptive Theories of Reasoning

- Prescriptive theories of reasoning are concerned with prescribing methods for optimal decision making. They characterize how people should make decisions and judgments. For example, the rational choice theory in economics (of which game theory is but one part) is prescriptive. Makes extensive use of mathematics and statistics.
- Descriptive theories are based on descriptions of what people actually do when they make decisions and judgments. Characterizes people as intuitive statisticians bounded in their rationality.
- Since we are interested in studying errors and biases in judgment making, how do we demonstrate that a particular inference of judgment is faulty? Answer: we compare it with the prescriptive ideal under the rational model, and if it deviates from those standards, we have greater confidence the judgment is flawed.

2. Rational Decision Making (Six Step Process)

- Define the Problem. Must avoid (a) solving the wrong problem; (b) defining the problem in terms of proposed solution; (c) diagnosing problem in terms of its symptoms.
- Identify the Criteria. Most problems have multiple objectives.
- Weight the Criteria. The criterion are of varying importance. Must attach a value to each of them.
- Generate Alternatives. This requires search, but frequently you don’t have time to search to long.
- Rate Alternatives on each Criterion. Usually requires forecasts or estimates as to how effective each alternative will be on each criterion.
- Calculate Optimal Decision.
Simple Example: Buying a car.

The relevant criteria are the following: reputation, comfort, safety, cost, and fuel efficiency.

Suppose we weight the criteria by assigning probabilities (i.e., weights) to each criterion as follows:

1. cost – 8/16
2. safety – 3/16
3. comfort – 2/16
4. gas mileage – 2/16
5. reputation – 1/16

The alternatives are Honda vs. Volvo.

Suppose we rate each alternative on each criterion as follows:
Good (4), Medium (2), and Bad (1).

Honda:  
1. cost is Medium (2)
2. safety is Bad (1)
3. comfort is Med (2)
4. Gas is Good (4)
5. Reputation is Good (4)

Volvo:  
1. cost is Bad (1)
2. safety Good (4)
3. comfort Good (4)
4. gas Med (2)
5. rep Med (2)

Calculate: Multiply the weight of each criterion by the rank of each criterion for both alternatives. Honda gets a score of 2 and 3/16. Volvo gets a score of 2 and 2/16. Since Honda’s score is higher, buy Honda!

3. Expected Utility Theory (EUT)

- EUT is a prescriptive theory (much of game theory is built on it). It prescribes a way of determining what the best decision is. The following are simple examples.
Suppose you are given a choice between two games:

**Game A:** You have a 20% chance of winning $10, and an 80% chance of winning nothing.

**Game B:** You have a 10% chance of winning $50, and a 90% chance of winning nothing.

Which game do you play? Game A is more appealing than B because you have a greater chance of winning (20% vs. 10%), but Game B is more appealing than A because if you win, you get more money ($50 vs. $10). Thus, there are two separable dimensions of choice here: (1) the likelihood (or probability) of an outcome (let’s call it p); and (2) the value (or utility) of that outcome (let’s call it v). How do take both dimensions into account? With EUT, we multiply them together for each game and compare.

\[
\text{Expected Value} = (p) \times (v)
\]

Game A: 20% x $10 = $2  
Game B: 10% x $50 = $5

The prescriptive model tells us to go for Game B. This is exactly what people do when given a choice like this, in which the probabilities are fairly similar. Here, people are reasoning in accordance with the prescriptive model – they’re doing what they should be doing.

- But that’s not always the case. Consider a choice between these two games:

**Game C:** You have a 1% chance of winning $1000, and a 99% chance of winning nothing.

**Game D:** You have a 100% chance of winning $5, and a 0% chance of winning nothing.

Expected Value of Game C: 1% x $1000 = $10  
Expected Value of Game D: 100% x $5 = $5
According to EUT, people should choose Game C. But that’s not what happens in reality. You get a large proportion of people choosing Game D, because it involves a sure thing. Bottom line: people don’t like uncertainty, so they choose the sure thing – even if it costs them money. In other words, people can be risk-averse, at least when it comes to gains. We’ll show later that people may behave just the opposite when faced with choices involving losses. The idea that people are risk-averse in the realm of gains and risk-seeking in the realm of losses is just one example of the way people seem to behave.

4. Judgmental Heuristics

Cognitive psychologists have identified three simple heuristics, or rules-of-thumb, that people use to make judgments or draw inferences about the environment: (a) the availability heuristic; (b) the representative heuristic; and (c) the anchoring and adjustment heuristic. These mental short-cuts are efficient in the sense that they help to economize on cognitive effort and give roughly correct answers most of the time. But they can also give rise to large, predictable errors or biases in many cases. We’ll consider each of these heuristics in turn.

Before we do, however, consider some simple examples of heuristics.

- Blackjack players never “hit” on 17.
- Bankers give mortgage allowance based on 35% of household income.
- Never throw good money after bad.
- Red sky at night, sailors delight; red sky at dawn, sailors be warned.
- Baseball players never swing on a 3-0 count.

The list is endless. Most of the time they work, because peoples’ intuitive reasoning about statistics are generally correct. But sometimes these routines lead to wrong conclusions, and this can get you into trouble.
A. The Availability Heuristic

- We often estimate the probability of an event, or the frequency of a class of events, by the ease with which we summon examples from memory.

- Much of the time, there is a close positive correlation between the ease of recall and the true frequency of occurrence. It is easier, after all, to recall examples of things that happen often.

- But frequency of occurrence is not the only factor determining ease of recall.

- **Vividness** is another factor. Suppose you want a Swedish car, and your choice is Volvo or Saab. You’ve researched both cars by examining hundreds of reports from Consumer Reports. By all indications, Volvo seems have better record. Then you go to a family dinner party and your friend tells you about his personal experience with Volvo. What do you do?

- **Vividness** effects are enhanced by the media. We get a lot of our ideas about the likelihood of certain events – crime, winning the lottery, plane crashes, based entirely on media reports. But there is a very strong reporting bias.

- **Categorization schemes** also trigger availability. It’s easy to find “history” books in the library than books about “strategic failures” because history books are part of the library’s cataloguing system. What’s true for the library also holds true for personal memory – the retrieval structure can bias estimates.

- **Consequences:** People tend to assume that readily available instances, example or images represent unbiased estimates of statistical probabilities. It can bias estimates of relationships, such as causal relationships, correlation, and trends.

- The availability heuristic also explains why “first impressions” are so important. People will “size you up” according to how
closely your traits, characteristics, mannerisms, and behaviour resemble others they can easily recall – for good or bad.

B. The Representative Heuristic

- The Representative Heuristic is a rule-of-thumb which helps us answer questions of the type, “What is the probability that object A belongs to class B?”

- We often judge probabilities by the degree to which A resembles B. The more object A is similar to class B, the more likely we think A belongs to B.

- A could be an instance, B a category.
- A could be a sample, B the population.
- A could be an individual, B a group.

- People who employ this heuristic basically follow the rule-of-thumb that says: “If look like a duck, walks like a duck … then it must be a duck.”

- A couple of examples common to managerial settings are i) managers predict success of a new product based on similarity of that product to past successful product types; and (ii) managers may hire a new employee based on similarity of that person to other productive employees of a certain type.

**Example 1**: Skippy is a shy person. Is Skippy more likely to be a librarian or salesman?

Suppose you know that half (50%) of all librarians are shy, but only 10% of all salespeople are shy.

Now suppose you find out that in the population, there are 9 times as many salespeople as librarians.
Example 2: Linda is 31 years old, single, outspoken, and bright. She majored in philosophy and was concerned about social justice and participated in antinuclear demonstrations.

Is Linda: A) A bank teller, or  
   B) A bank teller who is active in the feminist movement?

Example 3: Given two sequences of coin flips, which one appear more likely: A) H-H-H-H-H, or  
   B) H-T-H-T-H.

Example 4: A certain town is served by two hospitals. In the larger one, 45 babies are borne each day; the smaller one, 15 babies are borne each day. 50% of babies are boys, but the exact percentage varies from day to day. For 1 year, each hospital recorded the days on which more than 60% of the babies borne were boys. Which hospital recorded more such days?  
   A) The larger hospital.  
   B) The smaller hospital.  
   C) About the same (within 5% of each other).

Each of these examples illustrates an important bias emanating from the representative heuristic, and these biases reduce one’s ability to make effective judgements under uncertainty.

Example 1: If you’re like most people, you answered: librarian. Psychologists have found that as amount of detail in scenario increases, its probability decreases but its representativeness and hence its apparent likelihood may increase. In other words, more details makes an instance/sample/individual less probable of belonging to a certain class (category/population/group), but somehow makes it seem more plausible. More detail somehow distracts people from taking account of base-rate information.

Bias 1: Insensitivity to Base-Rate Information

There’s more salesman in the overall population than librarians. People give too little weight to the frequency with which an event will occur. At the same time, people give too much weight to the notion that librarians tend to be shy and salesman are not.
**Example 2:** If you’re like most people, you probably answered: Linda is a bank teller. This, of course, is correct. When people face only two choices, they tend to realize when one event includes the other. In other words, in very simple settings people tend to understand that probability follows the conjunction rule: \( P(A \cap B) \leq P(B) \), i.e., the probability of A and B occurring together must be less than or equal to the probability of B occurring alone. A problem arises, however, when people face more than two choices. When those two propositions are crowded by other choices, we use the representative heuristic, and extra weight is given to the fact that Linda fits our notion of what a feminist activist looks like. This leads to a second bias emanating from the representative heuristic, called the conjunction fallacy.

**Bias 2: The Conjunction Fallacy**

People give too much weight to the likelihood of a conjunction (a combination of two or more descriptors occurring at the same time). A conjunction cannot be more probable than any one of its descriptors.

**Example 3:** If you’re like most people, you answered: (B). People tend to think that the outcome of a randomly generated process should look random, even for a small sample. However, a sequence of coin-flips, if the coin is fair, is equally likely to generate outcome (A). Each flip of the coin is a statistically independent event. This examples leads to a third bias emanating from the representative heuristic, called the Gambler’s Fallacy.

**Bias 3: Gambler’s Fallacy and the Hot-Hand Fallacy.**

These biases occur because of a misconception about chance. People tend to believe that the outcome of a random event should look random, and if it’s not, the outcome will tend to self-correct. If the last ten balls have been black at the roulette wheel, people think a red ball is “due.” If the last four people hired for a given job have been “duds,” people overestimate the likelihood the next person hired will be a good performer.

The same goes for the so-called hot-hand. A classic example here is stock picking. When investing in a mutual fund, for example, people over-
on recent performance; they pick the fund whose growth was highest in, say, the last year. But looking at average performances over many years is a much more successful strategy. This follows because stock picking has a significant random element to it, so streaks (good or bad) can occur because of chance alone.

**Example 4:** If you’re like most people, you answered: (C) about the same (within 5% of each other). People seem to have some idea as to how unusual it is to have 60% of a random event (with two outcomes) occurring in a specific direction. Yet, statistics tells us that it is much more likely to observe 60% male babies in a smaller sample than in a larger sample. Thus, the answer is (B). To make this point more intuitive, consider the outcome of a coin flip. Flipping a coin 10 times could quite easily generate 6 heads and 4 tails. But if you flip a fair coin 10,000 times, it would be highly unlikely to have the coin come up heads 6,000 times and tails only 4,000 times. This leads to a fourth representative bias concerning sample size, often called ‘belief in the law of small numbers.’

**Bias 4: Insensitivity to Sample Size; Belief in Law of Small Numbers.**

People assess the likelihood of a sample result by asking how similar that sample result is to the properties of the population from which the sample was drawn. The law of large numbers says that statistical descriptors (mean, standard deviation, etc.) of a sample tend to resemble the true descriptors of the population as long as the sample size is large enough. However, there is no corresponding law of small numbers. Nonetheless, with small sample sizes, people overestimate the likelihood that a sample result will resemble the population from which it is drawn.

You often hear advertisements stating something like the following. “Four out of five doctors agree: Aspirin is better at pain relief than Tylenol.” But they don’t tell you how large the sample size is. This would be more likely for small samples than for large samples.

For the record, scientists with a solid understanding of statistics make this mistake, overestimating the likelihood that small sample results will replicate on large samples.
Bias 5: Misconceptions of Regression to the Mean

One last bias emanating from the representative heuristic is the regression effect, or regression to the mean. We know from basic statistics that extreme outliers tends to regress toward the mean in subsequent trials (e.g., sons of unusually tall fathers tend to be shorter than their fathers, athletes with phenomenal rookie seasons tend to suffer from the “sophomore jinx,” mutual fund managers with unusually high rates of return on their portfolios tend to come back to earth the following year, etc.). Intuitively, however, people often expect subsequent trials to be representative of the previous trial, so we fail to anticipate regression to the mean.

An especially pernicious consequence of our failure to take into account regression to the mean is the effect it has on our estimates of the relative efficacy of praise and blame. Psychologists have long demonstrated that praise and other forms of positive reinforcement are much more effective than punishment or blame for teaching desired skills. But people would be unlikely to draw this conclusion from experience if they were unmindful of regression to the mean. The reason is that, quite independently of whether a person is praised or blamed, a very good performance is likely to be followed by a lesser one and a very bad performance is likely to be followed by a better one. Someone who praises good performances is likely to infer, erroneously, that praise perversely causes worse performance. Conversely, someone who punishes bad performances is likely, spuriously, to attribute to his or her action the improvement that in fact is the result of regression effects. Managers who are trying to get the best performance from their employees can ill afford to make this mistake.

How to Avoid Representative Bias:

- Don’t be misled by detailed scenarios and pay attention to base-rate information. Failure to do so leads people to overestimate low probability events (like conjunctions). It also distracts people from taking into account important information (like the frequency of occurrence of events).
- Always remember: chance is not self-correcting. Failure to understand this leads people to expect that the essential
characteristics of a random event will be represented not only globally in the entire sequence, but also locally in each of its parts.

• Don’t misinterpret regression towards the mean. Failure to do so can lead managers to misinterpret cause and effect, giving rise to perverse incentive structures.

C. The Anchoring and Adjustment Heuristic

• Another common strategy of estimation is “anchoring and adjustment.” People first choose a preliminary estimate – an anchor – and then adjust it in accordance with whatever additional information they have that appears relevant. Initial anchor may be chosen because of salience (see availability heuristic), how a problem is framed (see below), or partial computations.

• This procedure can lead to biased estimates for two reasons. First, the initial anchor may be unrelated to the value to be estimated. Second, even when it is related, people tend to adjust too little from it.

Example 1: Is the Fraser River more or less than 70 kilometres long? How long is it? Is the Fraser River more or less than 1000 kilometres long? How long is it?

Example 2: You are the project manager for a complex project that involves 10 independent steps for the overall project to be a success. Among other things, these steps include securing financing, selecting a location, market research, advertising, etc… You know that each step of the project has a 90% chance of being successful. What is the likelihood that the overall project will be a success?

Example 3: Same as example (2), but you are told that each step of the project has a 10% of failure. What is the probability that the overall project will be a failure?

Examples (1) – (3) all illustrate an important bias emanating from the anchoring and adjustment heuristic (but for different reasons): people make insufficient adjustment to the initial estimate or anchor.
**Bias 1a: Insufficient Anchor Adjustment**
When experiments are conducted with the questions given in example (1) people are unduly influenced by the suggested length. People use either the length of 70 or 1000 kilometres (depending on the question they get) to form an initial estimate and then make insufficient adjustment. Although the numbers given are arbitrary (the actual length of the Fraser is 1370 kilometres) they are used to estimate length nonetheless. This is because the numbers initially given are salient or immediately available to memory.

In examples (2) and (3), people form estimates as to the likelihood of project success or failure by using the probability of success or failure of a single step as an initial anchor and then adjust either down (with success) or up (with failure). Here, although the initial anchor is certainly related to the problem to be solved, insufficient adjustments are made, leading to a biased estimate as to overall likely success or failure.

**Bias 1b: Conjunctive and Disjunctive events Bias**

This bias is related to (1a). But we can generally predict what form these biases will take.

In Example (2), the problem is framed in terms of success of a project. The probability of overall project success is a conjunction of 10 independent steps being successful. Conjunctive probability questions take the general form, “What is the probability of having A and B and C … occur?” If steps 1 through 10 are labelled as steps A through J, the probability of all 10 being successfully completed is  
\[
P(A \text{ and } B \text{ and } C \ldots \text{ and } J) = P(A) \times P(B) \times P(C) \ldots \times P(J) = 0.9 \times 0.9 \ldots \times 0.9 = 0.35.
\]
That is, the probability of overall success is 35%. Most people anchor on 0.9 and then make insufficient adjustments downward. Thus, people tend to overestimate the probability of a conjunctive event.

In example (3), the problem is framed in terms of failure. When framed this way, the problem becomes one of determining the probability of a disjunction. Disjunctive questions take the general form, “What is the probability of having A or B or C … occur?” Here, if any of the individual steps fail, so does the project as a whole; that
is, if step A or B or C … or J fails, so does the project. One way of
determining the probability that a disjunction (A or B or C … or J)
will occur is to figure out the probability that it will not occur, and
subtract that amount from 1. We have already done that above. Thus,
the probability of overall failure is 1 – 0.35 = 0.65, or 65%. Example
(3) is exactly the same problem as example (2) – and has the same
answer, of course. But when the problem is framed in terms of failure,
most people anchor on the probability of failure of a given step (0.1)
and then make insufficient adjustment upward. Thus, people tend to
underestimate the probability of a disjunctive event.

Consequences:

- Anchoring with insufficient adjustment for a conjunctive event
can explain why people do things that seem likely and then
become surprised when it doesn’t turn out as planned.
- Anchoring with insufficient adjustment for a disjunctive event
helps explain our surprise when an apparently unlikely event
does in fact occur.
- Together, these two related biases help explain why small
businesses fail at the rate they do, and why projects often fail to
be completed on time and on budget. The framing effect here
merely determines the direction in which people fail to make
appropriate adjustment.
- These two biases also help explain why people are generally
over-confident about their ability.

How to Avoid the Anchoring and Adjustment Bias:

- Always view a problem from different perspectives.
- Think about the problem on your own before consulting others
in order to avoid becoming anchored by their ideas.
- Be careful to avoid anchoring your advisors, consultants, and
other from whom you solicit information for decision making.
- In adversarial relationships, anchoring is a common technique
in negotiations. Be wary of them. Think through your position
before any negotiations to avoid being anchored by the other
party’s initial proposal. At the same time, however, look for
opportunities to use anchors to your own advantage.