What does it mean to be *rational* or *reasonable* as opposed to *irrational* or unreasonable?
What does it mean to be rational or reasonable as opposed to irrational or unreasonable?

**Rationality** designates a capacity or set of capacities:
What does it mean to be *rational* or *reasonable* as opposed to *irrational* or unreasonable?

**Rationality** designates a capacity or set of capacities: an agent is *rational* to the degree that he or she possesses and manifests the relevant range of capacities.
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- the capacity to recognize or make correct judgements about reasons and other normative facts or truths
What does it mean to be rational or reasonable as opposed to irrational or unreasonable?

Rationality designates a capacity or set of capacities: an agent is rational to the degree that he or she possesses and manifests the relevant range of capacities.

- the capacity to recognize or make correct judgements about reasons and other normative facts or truths

- the capacity to reason well — to engage in “rational forms of reasoning”, to have one’s reflections and deliberations proceed in ways that satisfy various formal constraints.
We have already distinguished between **practical** and **theoretical** reasoning:

- Practical reasoning is reasoning directed toward action: figuring out what to *do*
- Theoretical reasoning is reasoning directed towards an *informational state*: figuring out how the facts stand.
We have already distinguished between **practical** and **theoretical** reasoning:

- **Practical reasoning** is reasoning directed toward action: figuring out what to *do*
- **Theoretical reasoning** is reasoning directed towards an *informational state*: figuring out how the facts stand.
Beliefs can represent the world more or less accurately....the more accurate the better.
Rational Beliefs

Beliefs can represent the world more or less accurately....the more accurate the better.

But we can also judge some beliefs as being more rational than others.
Rational Beliefs

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Rational Beliefs

Beliefs can represent the world more or less accurately. The more accurate the better.

But we can also judge some beliefs as being more rational than others.

Accuracy and rationality are linked, they are not the same: a fool may hold a belief irrationally — as a result of a lucky guess or wishful thinking — yet it might happen to be correct. Conversely, a detective might hold a belief on the basis of a careful and exhaustive examination of all the evidence and yet the evidence may be misleading, and the belief may turn out to be wrong.
Theoretical Reasoning

*Rational* beliefs are those that arise from **good thinking**, whether or not that thinking was successful in latching on to the truth.

But, what is **good thinking**?
Theoretical Reasoning

*Rational* beliefs are those that arise from *good thinking*, whether or not that thinking was successful in latching on to the truth.

But, what is *good thinking*?

- classical logic (modus ponens, modus tollens, etc.)
- non-monotonic/default logic
- closed-world reasoning
- induction (induction from examples)
- Abdunction (inference to the best explanation)
- Bayesian inference
- case-based reasoning/reasoning by analogy
- fast and frugal heuristics
Reasoning

Reasoning is a “transition in thought, where some beliefs (or thoughts) provide the ground or reasons for coming to another”

(1) Ann believes that Bill’s final grade is either a 6 or a 9.

(2) Ann believes that Bill’s final grade is not a 6.

So, (3) Ann believes that Bill’s final grade is a 9.

(1’) Bill’s final grade is either a 6 or a 9.

(2’) Bill’s final grade is not a 6.

So, (3’) Bill’s final grade is a 9.
(1) Bill brought his backpack to class every day of the semester.

So, [probably] (2) Bill will bring it to the next class.
(1) I need to catch the train at 9.09

Oh, (2) I better put the slides on the website.
What are the rules or formal constraints that govern *rational* transitions in thought?
Classical Logic and Rational Beliefs
Classical Logic and Rational Beliefs

- Cognitive limitations
Classical Logic and Rational Beliefs

- Cognitive limitations
- Are logically omniscient agents rational?
Classical Logic and Rational Beliefs

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Classical Logic: Inference Rules

Deductive cogency: a rational agent’s beliefs are logically consistent and closed under deduction
Classical Logic: Inference Rules

Deductive cogency: a rational agent’s beliefs are logically consistent and closed under deduction

Rules of inference:

- **Modus Ponens**: \( P, P \rightarrow Q \vdash Q \)
Deductive cogency: a rational agent’s beliefs are logically consistent and closed under deduction

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- **Modus Ponens**: $P, P \rightarrow Q \vdash Q$
- **Modus Tollens**: $\neg Q, P \rightarrow Q \vdash \neg P$
Classical Logic: Inference Rules

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- **Noncontradiction**: $P, \neg P \vdash Q$
- **Monotonicity**: $P \rightarrow Q \vdash (P \land R) \rightarrow Q$; $P \vdash Q$ implies $P, R \vdash Q$
The relationship between logical implication and what is reasonable to believe is very complex!
Inference and Reasoning vs. Implication and Consistency

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1. Ann believes that $P$ is true; Ann believes that $P \rightarrow Q$ is true; So, Ann (ought to, may, should, is rationally required to) believes that $Q$ is true

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A set of formulas is inconsistent if there is no way of making all of the formulas true

1. Ann recognizes that $\{P, Q, R\}$ are inconsistent

2. $\{P, Q, R\}$ are inconsistent
Rationality versus genius

A, B, C imply D. Sam believes A, B, and C. But some does not realize that A, B, C imply D. In fact, it would take a genius to recognize that A, B, C ⊢ D. And Sam, although a rational man, is far from a genius.
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Cognitive limitations: rationality ≠ genius

- Are logically omniscient agents rational?
- Deduction reasoning may lead to revising
- Foundational issues
- Ordinary language challenges
- Psychology of reasoning
Clutter Avoidance

\[ P \vdash P \lor Q \]
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Our limits restrict the resources and times to devote to empirical search, testing and inquiry, as well as to the inference worth carrying out.
Clutter Avoidance

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From “It is raining in Tilburg” to “It is raining in Tilburg or Lily is in Amsterdam” is a valid inference. In fact, there are infinitely many such trivial consequences ($p, p \lor q, p \land p, p \land (q \land q), p \rightarrow p, p \lor q \lor r, \text{etc.}$), but these will just “clutter the mind”.

Clutter Avoidance

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Also, if one “looses” the origination of this disjunctive belief, one may be mislead to think that there is a special reason to believe Lily is in Amsterdam or there is a special connection between rain in Tilburg and Lily being in Amsterdam.
Classical Logic and Rational Beliefs

✓ Cognitive limitations: rationality ≠ genius
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Discovering a Contradiction

Sally believes $A, B, C$ and has just come to realize that $A, B, C \vdash D$. Unfortunately, she also believes for very good reasons that $D$ is false. So she now has reason to stop believing $A, B$ or $C$, rather than a reason to believe $D$. 
Reasoning May Lead to Revising

Modus Ponens: \( P, P \rightarrow Q \vdash Q \)
Reasoning May Lead to Revising

Modus Ponens: $P, P \rightarrow Q \vdash Q$

Suppose that Ann believes that if she will attend Yale, then she will become an atheist. She also believes that she will attend Yale.
Reasoning May Lead to Revising

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Reasoning May Lead to Revising

Modus Ponens: \( P, P \rightarrow Q \vdash Q \)

Suppose that Ann believes that if she will attend Yale, then she will become an atheist. She also believes that she will attend Yale.

She concludes that she will become an atheist.

*But although MP gives Ann a reason to believe the conclusion, it does not decide that she will believe it.* Instead of believing the conclusion, she may decide to drop her belief in the conditional.
“Reasoning is not the conscious rehearsal of argument; it is a process in which antecedent beliefs and intentions are minimally modified, by addition and subtraction, in the interests of explanatory coherence and the satisfaction of intrinsic desires.” (G. Harman, pg. 56, “Practical Reasoning”)
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Epistemic Closure

*Epistemic Closure EC*: If *i* knows that *P* and *i* knows that *P* implies *Q*, then *i* knows that *Q*.

---

Epistemic Closure

*Epistemic Closure EC*: If *i* knows that *P* and *i* knows that *P* implies *Q*, then *i* knows that *Q*.

(1) The animal I am looking at is a zebra.

(2) If the animal I am looking at is a zebra, then it is not a mule cleverly disguised to look like a zebra.

(3) The animal I am looking at is not a mule cleverly disguised to look like a zebra.

Transfer of Warrant


Eric Pacuit: Rationality (Lecture 3) 23/53
Transfer of Warrant

(1) The Smiths are making an extravagant wedding for their daughter.

(2) The Smiths are wealthy.

(3) In making the extravagant wedding, the Smith are not just appearing to be wealthy.

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▶ It *begs the question* to use (2) as a reason to believe (3).
▶ (1) can only provided evidence for (2) if (3) is presupposed
▶ The warrant or support that (1) lends to (2) does not *transmit* to the conclusion (3).

Dogmatism Paradox

“If I know that \( h \) is true, I know that any evidence against \( h \) is evidence against something that is true; I know that such evidence is misleading. But I should disregard evidence that I know is misleading. So, once I know that \( h \) is true, I am in a position to disregard any future evidence that seems to tell against \( h \).”

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1. My car is in the parking lot.
2. If my car is in the parking lot and Doug reports otherwise, then Doug’s report is misleading.
3. If Doug reports that my car is not in the parking lot, then his report is misleading.
4. Doug reports that my car is not in the parking lot.
5. Doug’s report is misleading.
Dogmatism Paradox

If there is evidence against my knowledge, then that evidence is mistaken or misleading.

\[ \neg p \rightarrow [(q \rightarrow \neg p) \rightarrow \neg q] \]
Dogmatism Paradox

If there is evidence against my knowledge, then that evidence is mistaken or misleading.

\[ \vdash p \rightarrow [(q \rightarrow \neg p) \rightarrow \neg q] \]

If my wife is cheating on me, I would never know.
The Scandal of Deduction

“... in addition to this scandal of induction there is an equally disquieting scandal of deduction.
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The Scandal of Deduction

“If that were correct, all that deductive inference could accomplish would be to render explicit knowledge that we already possessed: mathematics would be merely a matter of getting things down on paper, since, as soon as we had acknowledged the truth of the axioms of a mathematical theory, we should thereby know all the theorems. Obviously, this is nonsense: deductive inference has here been justified at the expense of its power to extend our knowledge and hence of any genuine utility.”


Classical Logic and Rational Beliefs

✓ Cognitive limitations: rationality $\neq$ genius
✓ Are logically omniscient agents rational? No.
✓ Deduction reasoning may lead to revising
✓ Foundational issues: the problem of epistemic closure, dogmatism paradox, the scandal of deduction
  ▶ Ordinary language challenges
  ▶ Psychology of reasoning
Ordinary Language Challenges

1. John goes drinking and John gets arrested.
2. John gets arrested and John goes drinking.

1. John will order either pasta or steak, but he order pasta.
2. John does not order steak.

1. If you tutor me in logic, I'll pay you 50 EUR.
2. If you don't tutor me, I won't pay you 50 EUR.
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Ordinary Language Challenges: Gricean Implicature

He [the speaker] has said that p; there is no reason to suppose that he is not observing the maxims, or at least the Cooperative Principle; he could not be doing this unless he thought that q; he knows (and knows that I know that he knows) that I can see the supposition that he thinks that q is required....he intends me to think...that q; and so he has implicated q.

Cooperative Principle: The speaker intends his contribution to be informative, warranted, relevant and well formed.

Classical Logic and Rational Beliefs

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Wason Selection Task

You are shown a set of four cards placed on a table, each of which has a number on one side and a letter on the other side. Also below is a rule which applies only to the four cards. Your task is to decide which if any of these four cards you must turn in order to decide if the rule is true. Don’t turn unnecessary cards.

Rule: If there is a vowel on one side, then there is an even number on the other side.
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- A  
- K  
- 4  
- 7
**Rule:** If there is a vowel on one side, then there is an even number on the other side.

Which card(s) should we turn over?

1. A
2. A and 4
3. K and 4
4. A and 7
5. All of them
6. Other
**Rule:** If there is a vowel on one side, then there is an even number on the other side.

Which card(s) should we turn over?

1. A
2. A and 4 (half the subjects)
3. K and 4
4. A and 7 (Very few)
5. All of them
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\[
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& P & Q & P \rightarrow Q \\
1 & 1 & & 1 \\
1 & 0 & & 0 \\
0 & 1 & & 1 \\
0 & 0 & & 1 \\
\end{array}
\]

P: vowel
Q: even number

Eric Pacuit: Rationality (Lecture 3)
Wason Selection Taks: Analysis

- Reasoning to an interpretation vs. reasoning from an interpretation
- How do people interpret rules or if, then statements?

“Common Sense” Reasoning

(1) Bill brought his backpack to class every day of the semester.
So, [probably] (2) Bill will bring it to the next class.

(3.1) Tweety is a penguin.

(3) Tweety is a bird
So, (4) Tweety flies.
“Common Sense” Reasoning

(1) Bill brought his backpack to class every day of the semester.

So, [probably] (2) Bill will bring it to the next class.

(1.1) Bill’s backpack was stolen.

(3) Tweety is a bird

(4) Tweety flies.

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Beyond Classical Logic
Beyond Classical Logic

- Non-classical rules
- Reasoning under uncertainty/“common-sense reasoning”
- Foundational issues
- Common fallacies
Non-Monotinicity

If $A \vdash B$ holds then $A, C \vdash B$ also holds.

Conclusions that are reasonable on the basis of specific information can become unreasonable if further information is added.

Given the announced schedule for the course, and your previous experience, and that today is Thursday, it is reasonable to conclude that the course will meet in the evening.

However upon learning there is an announcement on the website that class is canceled, then it is reasonable to drop this belief.

Further, if it is discovered that there was a mistake on the website, then it is reasonable to believe that there will be class.

$A \rightarrow B \vdash (A \land C) \rightarrow B$

‘If you put sugar in the coffee, then it will taste good’ can be true without ‘If you put sugar and gasoline in the coffee, then it will taste good’ being true.
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If $A \vdash B$ holds then $A, C \vdash B$ also holds.

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Closed-world reasoning

Negation as failure
Suppose you are interested in whether there are any direct flights from Amsterdam to Cleveland, Ohio.
After searching online at a number of relevant sites (Expedia, Orbitz, KLM, etc.), you do not find any. You conclude that there are no direct flights between Amsterdam and Cleveland.
Beyond Classical Logic

✓ Non-classical rules: non-monotonicity, closed-world reasoning
  ▶ Induction/“common-sense reasoning”
  ▶ Foundational issues
  ▶ Common fallacies
Induction

*Enumerative Induction*
Given that all observed $F$s are $G$s, you infer that all $F$s are $G$s, or at least the next $F$ is a $G$.

*Inference to the best explanation*
Holmes infers the best explanation for footprints, the absence of barking, the broken window: ‘The butler wears size 10 shoes, is known to the dog, broke the window to make it look like a burglary...’

*Scientific hypothetic induction*
Scientists infer that Brownian motion is caused by the movement of invisible molecules.
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▸ Foundational issues
▸ Common fallacies
Hume: Does positive inductive evidence support rational beliefs?

In the past, $F$s have been followed by $G$s (and never by non-$G$s)

So, the present case of an $F$ will be followed by a $G$
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UN: Nature is uniform (at least in regard to $F$s followed by $G$s).

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In the past, nature has been uniform (at least in regard to $F$s followed by $G$s)

The present case is an instance of that uniformity

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The Ravens Paradox

(IC) A hypothesis of the form “All As are Bs ($\forall x (A(x) \rightarrow B(x))$)” is confirmed by any positive instance “$Aa \& Ba$”.

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$H$: All ravens are black.

$H'$: All nonblack things are nonravens.
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*But, then does a red jacket confirm $H$?*
Goodman’s New Riddle of Induction

All emeralds examined thus far are green.
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This leads us to conclude (by induction) that (H1) all emeralds are green, and every next green emerald discovered strengthens this belief.
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Suppose that $t$ is some time in the future. Let H2 be “all emeralds are grue”.
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The data collected thus far seems to confirm H1 as well as H2, but H1 seems to be a “better explanation” ...

Probabilities

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e supports $h$ if the probability of $h$ given $e$ and the background information is greater than the probability of $h$ given the background information alone:

$$p(h \mid e \& b) > p(h \mid b).$$
Beyond Classical Logic

✓ Non-classical rules: non-monotonicity, closed-world reasoning
✓ Induction/“common-sense reasoning”: default logic, non-monotonic logic, inductive logic, defeasible reasoning, Bayesian inference, reasoning under uncertainty, etc.
✓ Foundational issues: Hume, paradox of the ravens, Goodman’s new paradox of induction

► Common fallacies
Conjunction Fallacy

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.
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Typically a large percentage of people asked say 2 is more probable than 1.

Base-Rate Fallacy

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Suppose somebody triggers the alarm. What is the chance he/she is really a terrorist?

Common Answer:

$$p(T|B) = p(B|T) \cdot \frac{p(T)}{p(T) \cdot p(B|T) + p(B|\neg T) \cdot p(\neg T)} = \frac{0.99 \cdot 100}{0.99 \cdot 100 + 0.01 \cdot 999900} \approx 0.98\%.$$
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In an attempt to catch the terrorists, the city installs a surveillance camera with automatic facial recognition software. If one of the known terrorists is seen by the camera, the system has a 99% probability of detecting the terrorist and ringing an alarm bell. If the camera sees a non-terrorist, it will only incorrectly trigger the alarm 1% of the time.
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- Foundational issues: Hume, paradox of the ravens, Goodman’s new paradox of induction
- Common fallacies: the Linda problem, base-rate fallacy
Conclusions: Rules of Reasoning

- **Normative**: reasoning as it should be, ideally
  - Modus Tollens, Bayes Theorem

- **Descriptive**: reasoning as it is actually practiced
  - many people do not endorse Modus Tollens or make base rate fallacies

- **Prescriptive**: take into account bounded rationality
  - computational limitations, storage limitations
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- Reasoning rarely happens in real life: we have developed “fast and frugal algorithms” which allow us to take quick decisions which are optimal given constraints of time and energy.
Conclusion

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Next Week: Practical Reasoning and Reasons for Action