

Basics of Logic

Empirical & Theoretical Research Methodology
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Overview & Learning Goals

- You understand the **relevance of logic** to management studies and decision making in a management context
- You understand how an **argument** is constructed and the most important (technical) terms in logic
- You understand basic propositional logic **operators** and know how to formalize a text into the form of the logical operators

What is Logic?

Logic is ...

... an integral part of Philosophy

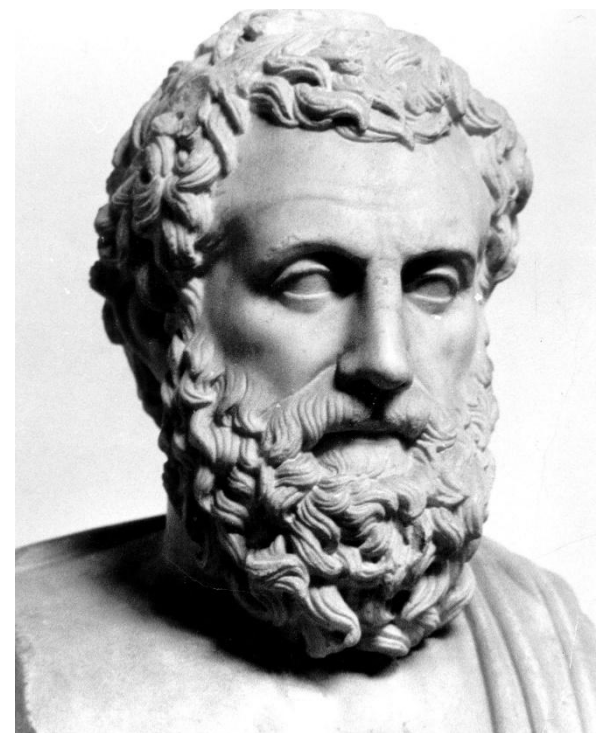
... a science with many sub-fields

... the analysis and evaluation of arguments

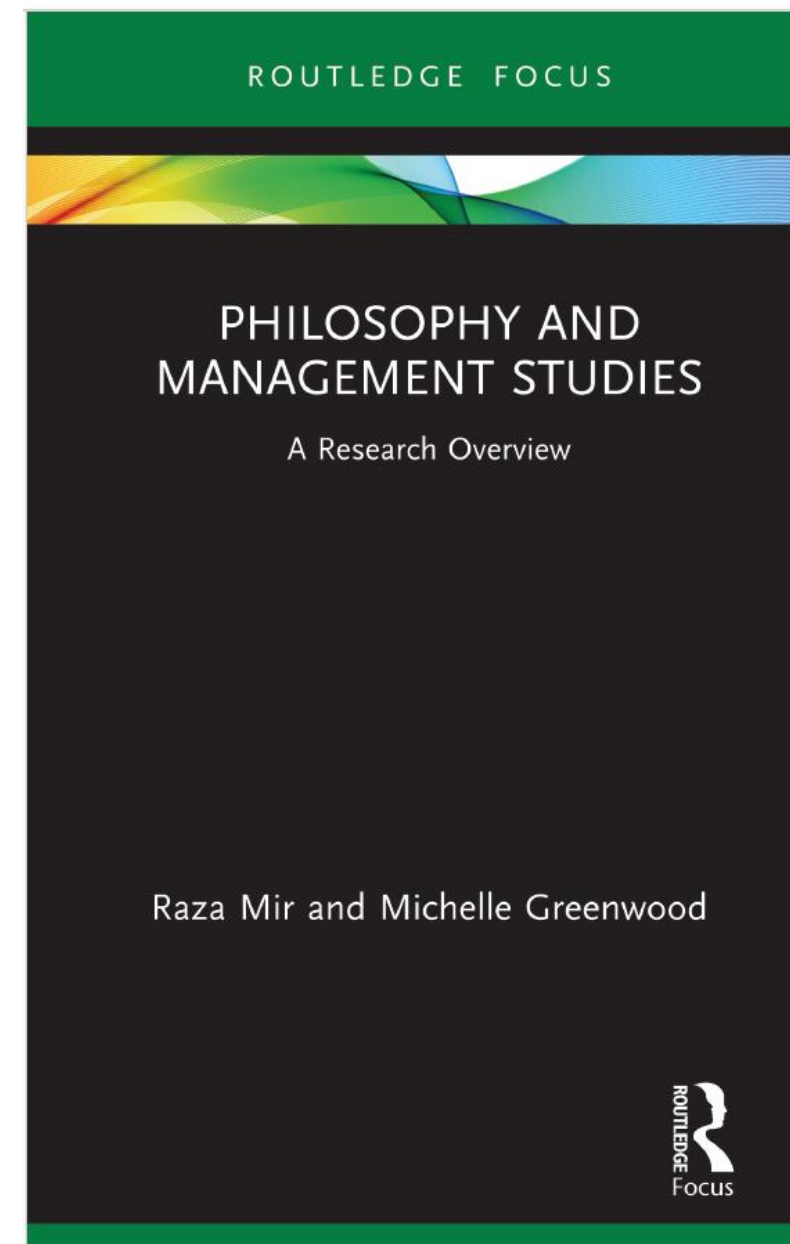
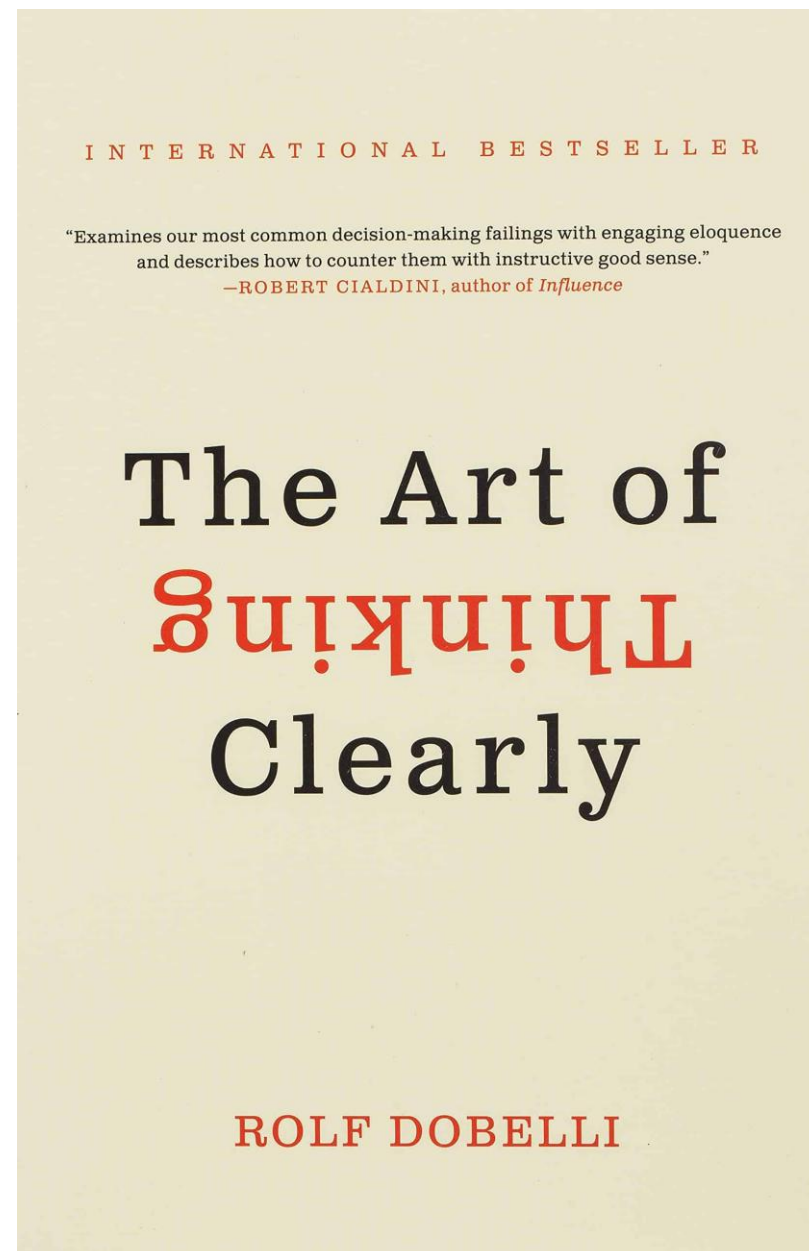
Propositional Logic: the study of the **meanings** of, and the inferential **relationships** that hold among, **sentences** based on the role of logical operators (**propositional connectives**) have in determining those sentences' **truth** conditions.

Why study logic?

- Improve your own argumentation and analytical skills
- Improve your understanding of other people's arguments



Example: Management Studies & Logic



Arguments

*"An argument, in the sense used in logic, is a set of **statements consisting of premises and a conclusion**. The premises are statements that (are intended to) give supporting evidence; the conclusion is what is allegedly supported by these statements."*
[Source].

1. Premise(s) = a **declarative statement** that provide support for the conclusion

We can assign a **truth value** to the premise, but the premise does not have to be true for the argument to be work

2. Conclusion

Example: Arguments I

You ordered mint-flavored ice-cream?! (this is a question – an emotionally loaded one)

This statement is false. (this is the liars paradox)

The old believe everything; the middle-aged suspect everything; the young know everything. (Oscar Wilde) (This is a nice remark, not an argument, because it is not a set of statements where one is intended to be supported by the others.)

The atomic number for hydrogen is 1 and the atomic number for helium is 2.
(this is a connection of two statements, it could function as a premise)

Example: Arguments II

Premise 1: If it rains, the street is wet

Premise 2: It rains

Conclusion: The street is wet

Premise 1: If Sabrina loves Alex, Sabrina always orders the ice cream Alex likes

Premise 2: Alex does not like mint-flavored ice cream

Premise 3: Mint-flavored ice cream tastes like toothpaste

Premise 4: Sabrina always orders mint-flavored ice cream

Conclusion: Sabrina does not love Alex

Example: Arguments II

Premise 1: If it rains, the street is wet

Premise 2: It rains

Conclusion: The street is wet

Premise 1: If Sabrina loves Alex, Sabrina always orders the ice cream Alex likes

Premise 2: Alex does not like mint-flavored ice cream

~~Premise 3: Mint-flavored ice cream tastes like toothpaste~~

Premise 4: Sabrina always orders mint-flavored ice cream

Conclusion: Sabrina does not love Alex

Example: Arguments III

Premise 1: Mint-flavored ice cream tastes like toothpaste

Premise 2: Ice cream that tastes like toothpaste is disgusting

Conclusion: Mint-flavored ice cream is disgusting

Example: Arguments III

Premise 1: Mint-flavored ice cream **tastes like toothpaste**

Premise 2: Ice cream that tastes like toothpaste is **digusting**

Conclusion: Mint-flavored ice cream is distugsting

Premise 1: Eating our friends is wrong.

Premise 2: Dogs are our friends.

Conclusion: Eating dogs is wrong.

Take Aways

- Each argument has exactly one or more premises
- The premises are statements, claims, sentences, proposition
- They are declarative sentences, not questions, not exclamations, no imperatives. Only declarative sentences can be evaluated unambiguously, the other types of statements are ambiguous and thus impossible to evaluate.
- A premise is always a statement that is either true or false but not both. Otherwise, it would be a paradox. Paradoxes are statements that cannot be assigned a truth value, for example: “I always lie” or “This statement is false”
- The premises have a function, namely they are intended to provide support for, or reason to believe, the conclusion.
- Truth of the premise is not a condition for an argument: Although the premises might be wrong, it is still an argument – but not a valid argument. – this is what we will look into more next session when we talk about the evaluation of arguments.

Arguments vs Explanations

Argument = **what** are the **reasons** to believe a conclusion?

Explanation = **why** is a conclusion **true** (or false)?

The lights went out because there was a power outage.

The suspect must be guilty because their fingerprints were at the scene.

Arguments vs Explanations

Argument = **what** are the **reasons** to believe a conclusion?

Explanation = **why** is a conclusion **true** (or false)?

The lights went out because there was a power outage. (E)

The suspect must be guilty because their fingerprints were at the scene. (A)

Argument vs Interpretation

Argument = **what** are the **reasons** to believe a conclusion?

Explanation = **why** is a conclusion **true** (or false)?

Interpretation = what could this sentence **mean**?

Definition = what **is** p?

Lexical Definition = explaining current usage

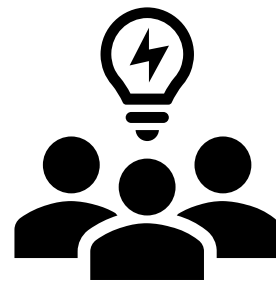
Stipulative Definition = specifying usage for a particular context

Short Discussion

Can you think of situations in which you struggled to argue for your position?

In what ways can knowledge about arguments help you in these situations?

5 Minutes Discussion



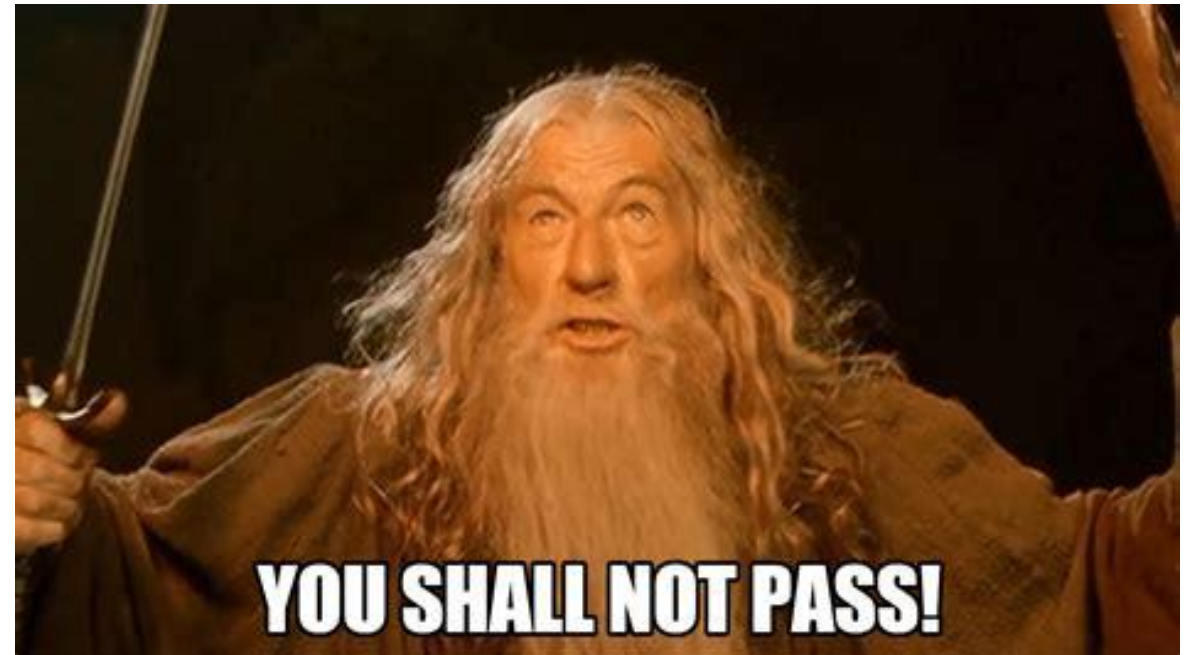
Basic Logical Operators

Some notes on writing logic:

- Use symbols to represent statements (p , q , s , ...)
- Conclusion separated from premises with a line (or $\therefore$)
- Use **logical operators** to combine statements
- Assign truth values (T, F) to the statements to then assess their validity (**truth tables**)

Basic Logical Operators

$\neg$ negation (not)



$p \Rightarrow$ you shall pass

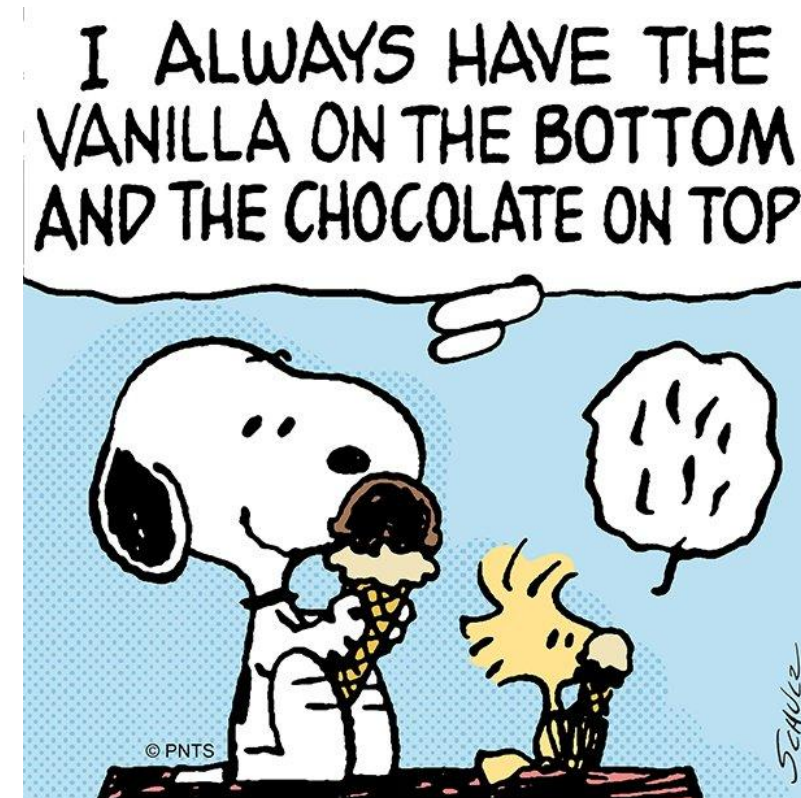
$\neg p \Rightarrow$ you shall not pass

For $\neg p$ to be true, p needs to be false.
For $\neg p$ to be false, p needs to be true.

Basic Logical Operators

$\neg$ negation (not)

$\wedge$ conjunction (and)



Chocolate ice cream $\Rightarrow$ p
Vanilla ice cream $\Rightarrow$ q

$$p \wedge q \equiv q \wedge p$$

For $p \wedge q$ to be true, we need both p and q to be true

Basic Logical Operators

$\neg$ negation (not)

$\wedge$ conjunction (and)

$\vee$ disjunction (or)



The maid did it $\Rightarrow p$
The butler did it $\Rightarrow q$

$$p \vee q \equiv q \vee p$$

For $p \vee q$ to be true, we need at least one of the two propositions p, q to be true

Truth Tables I

Truth Table for Negation

	P	$\sim P$
Case 1	T	F
Case 2	F	T

Truth Table for Conjunction

	P	Q	$P \wedge Q$
Case 1	T	T	T
Case 2	T	F	F
Case 3	F	T	F
Case 4	F	F	F

Truth Table for Disjunction

	P	Q	$P \vee Q$
Case 1	T	T	T
Case 2	T	F	T
Case 3	F	T	T
Case 4	F	F	F

Logical Truths

- $p \wedge \neg p$ is a contradiction

because: for $p \wedge q$ to be true, we need both p and q to be true

- $p \vee \neg p$ is a tautology

because: for $p \vee q$ to be true, we need at least one of the two propositions to be true

Basic Logical Operators

$\neg$ negation (not)

$\wedge$ conjunction (and)

$\vee$ disjunction (or)

$\rightarrow$ conditional (if then)



“If you complete the project by Friday, I’ll give you a bonus.”

You complete the task by Friday $\Rightarrow p$

You get a bonus $\Rightarrow q$

$p \rightarrow q \neq q \rightarrow p$

If p is true, $p \rightarrow q$ takes the truth value of q .
If p is false, $p \rightarrow q$ is true by definition.

Truth Tables II

Truth Table for Negation

	P	$\sim P$
Case 1	T	F
Case 2	F	T

Truth Table for Conjunction

	P	Q	$P \wedge Q$
Case 1	T	T	T
Case 2	T	F	F
Case 3	F	T	F
Case 4	F	F	F

Truth Table for Disjunction

	P	Q	$P \vee Q$
Case 1	T	T	T
Case 2	T	F	T
Case 3	F	T	T
Case 4	F	F	F

Truth Table for Conditional

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

Truth Tables II

Truth Table for Negation

	P	$\sim P$
Case 1	T	F
Case 2	F	T

Truth Table for Conjunction

	P	Q	$P \wedge Q$
Case 1	T	T	T
Case 2	T	F	F
Case 3	F	T	F
Case 4	F	F	F

Truth Table for Disjunction

	P	Q	$P \vee Q$
Case 1	T	T	T
Case 2	T	F	T
Case 3	F	T	T
Case 4	F	F	F

Truth Table for Conditional

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

Common Syllogisms

A Syllogism is a valid deductive argument having two premises and a conclusion.

Modus Ponens

Premise 1: If it rains, the street is wet

Premise 2: It rains

Conclusion: The street is wet

$P \rightarrow Q$
 P
 $\therefore Q$

Think of: a syllogism as a small, tightly controlled argument

Common Syllogisms

A Syllogism is a valid deductive argument having two premises and a conclusion.

Modus Tollens

Premise 1: If our pricing strategy is competitive, sales will increase.

Premise 2: Sales have not increased.

Conclusion: Our pricing strategy is not competitive.

$$P \rightarrow Q$$
$$\neg Q$$
$$\therefore \neg P$$

Common Syllogisms

A Syllogism is a valid deductive argument having two premises and a conclusion.

Hypothetical Syllogism

Premise 1: If I do not wake up, then I cannot go to work

Premise 2: If I cannot go to work, then I will not get paid

Conclusion: If I do not wake up, then I will not get paid

$P \rightarrow Q$

$Q \rightarrow R$

$\therefore P \rightarrow R$

Common Syllogisms

A Syllogism is a valid deductive argument having two premises and a conclusion.

Disjunctive Syllogism

Premise 1: I eat soup today or I eat salad today

Premise 2: I do not eat soup today

Conclusion: I eat salad today

$P \vee Q$

$\neg P$

$\therefore Q$

Syllogisms

- Syllogism
 - “Logischer Schluss”
 - Specific form: two premises and a conclusion
 - If the premises are true and the syllogism is valid, the conclusion must be true
 - *Think of it like language grammar*

$P \rightarrow Q$ P	$P \rightarrow Q$ $\neg Q$	$P \rightarrow Q$ $Q \rightarrow R$	$P \vee Q$ $\neg P$	$P \rightarrow Q$ $\neg P$	$P \rightarrow Q$ Q
$\therefore Q$	$\therefore \neg P$	$\therefore P \rightarrow R$	$\therefore Q$	$\therefore \neg Q$	$\therefore P$
P1: If you touch the stove, you'll get burned P2: You touch the stove $\therefore$ You got burned	P1: If the store was open, lights would be on P2: Lights are not on $\therefore$ The store is not open	P1: If you miss the bus, you will be late for work P2: If you're late for work, you'll get fired $\therefore$ If you miss the bus, you'll get fired	P1: You pay the bill or your power gets shut off P2: You didn't pay the bill $\therefore$ Your power gets shut off	P1: If you study hard, you'll pass the test P2: You didn't study hard $\therefore$ You won't pass the test	P1: If she is a genius, she has good grades P2: She got good grades $\therefore$ She is a genius
Modus Ponens	Modus Tollens	Hypothetical Syllogism	Disjunctive Syllogism	Fallacy of the inverse	Fallacy of the converse

Summary

- Arguments and their fundamental structure
- Logical operators and syllogisms

Next week:

- Evaluation of arguments & argumentation

References

Slide 5: Gensler, Harry J. (2010) Introduction to Logic, 2. Edition, Routledge.
Page 2.