INTRODUCTION TO LOGIC

Lecture 3

Formalisation in Propositional Logic

Dr. James Studd

There is no other way to learn the truth
than through logic
Averroes

Outline

1. Truth-functionality
2. Formalisation
3. Complex sentences
4. Ambiguity
5. Validity of English arguments

English connectives

Recall that connectives join one or more sentences together to make compound sentences.

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These correspond to the connectives of $\mathcal{L}_1$: $\neg$, $\wedge$, $\vee$, $\rightarrow$, $\leftrightarrow$

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- ‘Pope Benedict XVI thought that’
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Only some English connectives can be captured in $\mathcal{L}_1$.
None of these connectives can be.

Truth functionality

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A_1 V. Halbach is giving this lecture.

A_2 Two plus two equals five.

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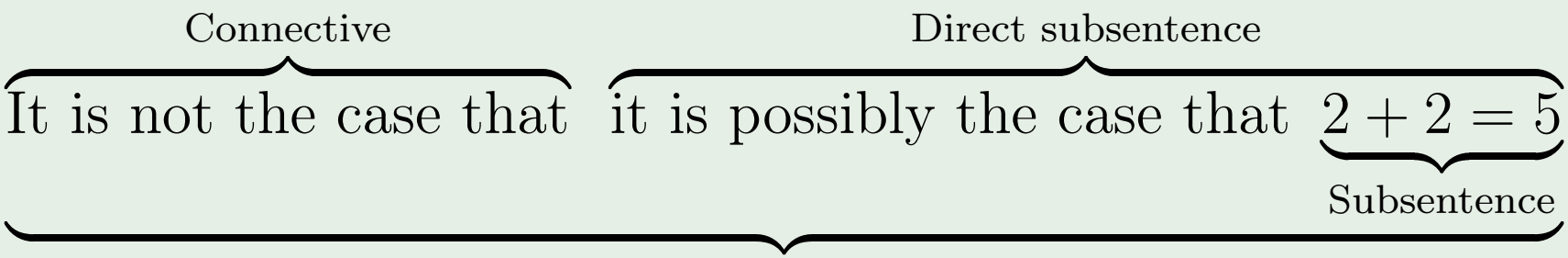

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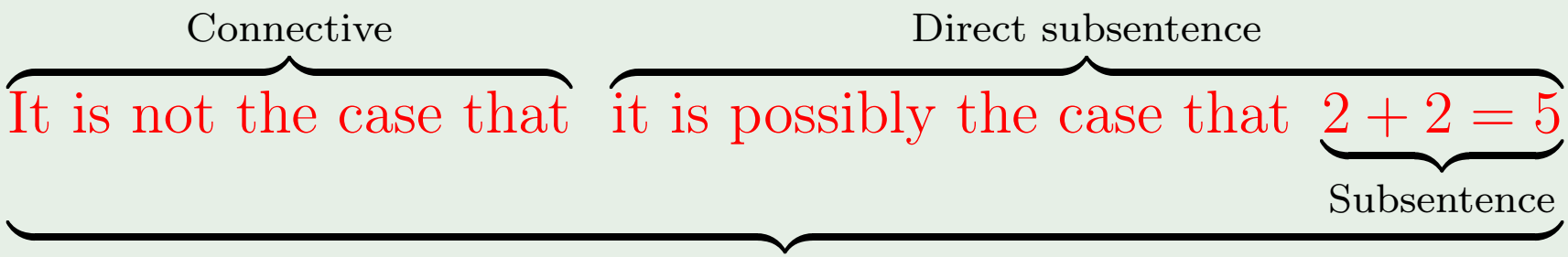

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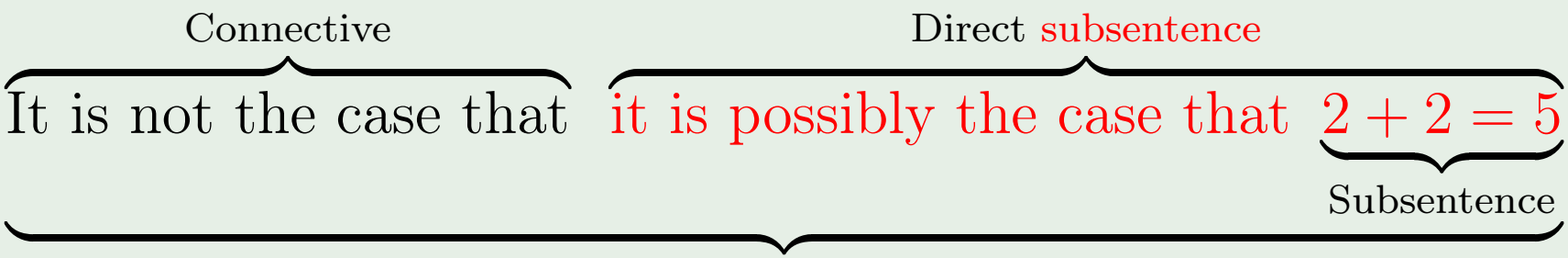

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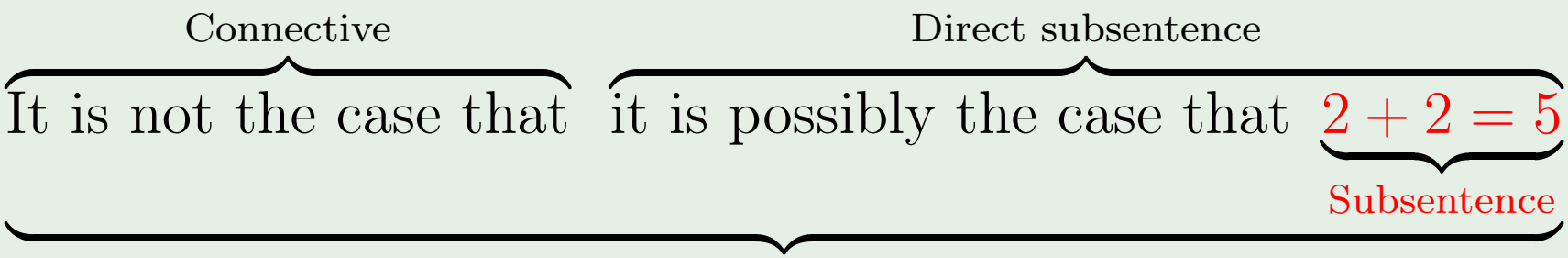

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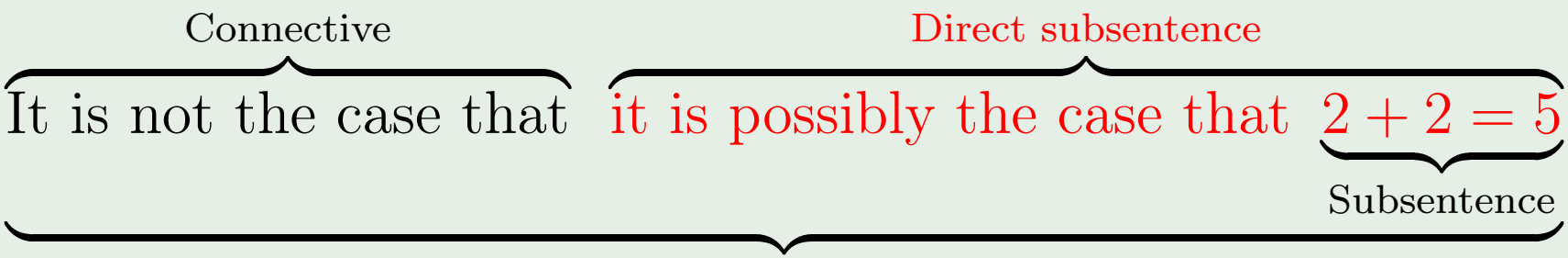

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Connective: "It is not the case that"
Direct subsentence: "it is possibly the case that $2 + 2 = 5$"
Subsentence: "$2 + 2 = 5$"
Compound Sentence: "It is not the case that it is possibly the case that $2 + 2 = 5$"

Direct subsentence: "It rains"
Connective: "and"
Direct subsentence: "sometimes it snows"
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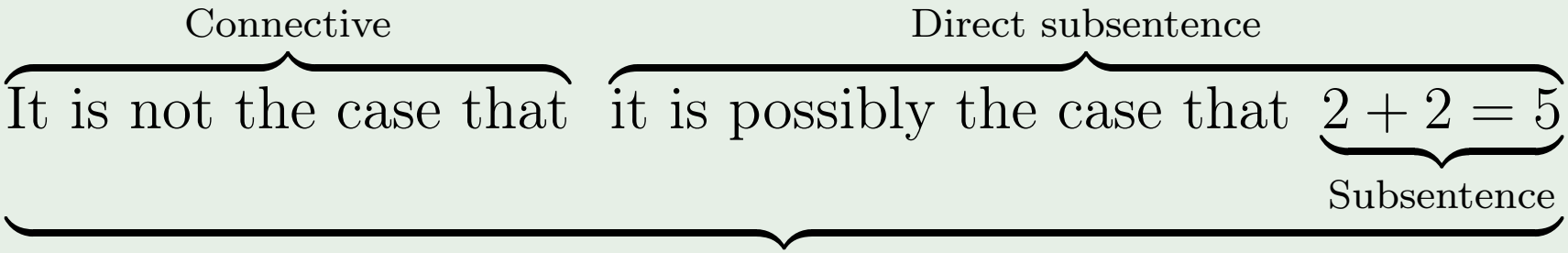

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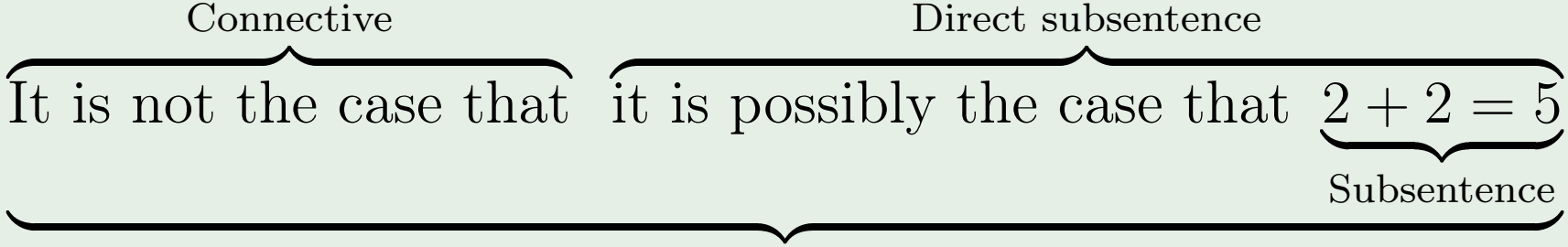

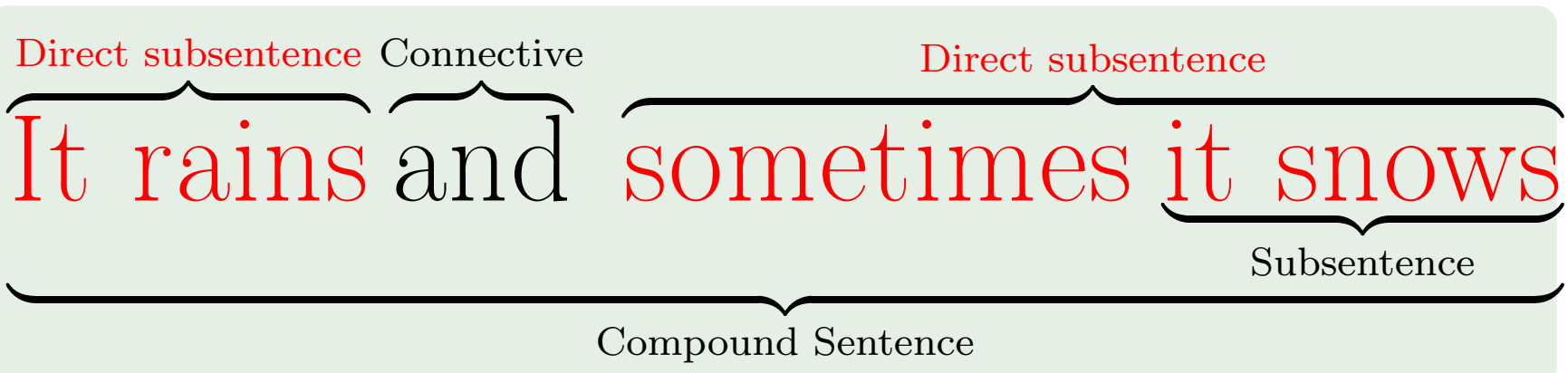

NB: replacing non-direct subsentences may change the truth-value.

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Formalisation
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Dictionary
R: Russell likes logic.

Formalise:

Russell likes logic and philosophers like conceptual analysis.

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$(\boldsymbol{R} \wedge \boldsymbol{P})$

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Note: it's fine to use letters other than P, Q, R when formalising English sentences.

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Neither Russell nor Whitehead likes logic.

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Common variants

Here are some of the most common variants of the standard connectives.

$\mathcal{L}_1$	standard connective	some other formulations
$\wedge$	and	but, although
$\vee$	or	unless
$\neg$	it is not the case that	not, none, never
$\rightarrow$	if ... then	provided that, only if
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Rules of thumb for $\rightarrow$

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(1) If John revised, [then] he passed. $R \rightarrow P$

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(3) Paraphrase: If John passed, John revised.

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'If' mid-sentence corresponds to '$\leftarrow$'; 'only if' to $\rightarrow$.

Differences between $\rightarrow$ and 'if'

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Formalise

If the lecturer hadn't shown up last week, Plato would have given the lecture.

Differences between $\rightarrow$ and 'if'

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If the lecturer hadn't shown up last week, Plato would have given the lecture.

Consider: $\neg S \rightarrow P$.
Dictionary: S: The lecturer showed up last week.
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The English sentence appears to be false.

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P: Plato gave the lecture.

The English sentence appears to be false.
But when $|S|_{\mathcal{A}} = \mathrm{T}$, $|\neg S \rightarrow P|_{\mathcal{A}} = \mathrm{T}$.

Differences between $\rightarrow$ and 'if'

Formalise

If the lecturer hadn't shown up last week, Plato would have given the lecture.

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See Sainsbury, *Logical Forms*, ch. 2 for further discussion.

Complex Sentences

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Formalise

If David folded or David didn't have the ace, Victoria won.

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Logical Form

(If ((David folded) or it is not the case that (David had the ace)), (Victoria won))

This is in (propositional) logical form.

- All connectives are standard connectives
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Formalisation: $((\boldsymbol{F} \vee \neg \boldsymbol{A}) \rightarrow \boldsymbol{W})$
Dictionary: F: David folded.
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Sometimes the paraphrase may need to be quite loose.

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Example

David's hand was weak and Victoria was bound to win unless the Jack came up on the turn.

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In (1): $\vee$ has wider scope.
In (2): $\wedge$ has wider scope.

More on paraphrase

(1) Tom and Jerry are animals.
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(3) Jerry is a white mouse.
(4) Jerry is a large mouse.

Worked example: are these acceptable paraphrases?

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Logical notions in English

Recall last week's definitions of tautology, contradiction and validity for $\mathcal{L}_1$ sentences and arguments.

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These properties of $\mathcal{L}_1$ can be transposed to English.

Definition

(1) An English sentence is a tautology if and only if its formalisation in propositional logic is a tautology.

(2) An English sentence is a propositional contradiction if and only if its formalisation in propositional logic is a contradiction.

(3) An argument in English is propositionally valid if and only if its formalisation in $\mathcal{L}_1$ is valid.

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Show that the following argument is propositionally valid.

Unless CO_2-emissions are cut, there will be more floods. CO_2-emissions won't be cut. Therefore there will be more floods.

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  Dictionary.
  C: CO_2 emissions will be cut.
  M: There will be more floods.
- Next, formalise the premisses and conclusion.
- Finally, check the formalised argument is valid.

Worked example (cont.)

P1 Unless CO_2-emissions are cut, there will be more floods.

P2 CO_2-emissions won't be cut.

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Formalise the argument:

P1 Paraphrase:
CO_2-emissions will be cut or there will be more floods.

Worked example (cont.)

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Formalise the argument:

P1 Paraphrase:
CO_2-emissions will be cut or there will be more floods.
Formalisation: $\boldsymbol{C \vee M}$.

Worked example (cont.)

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Formalise the argument:

P1 Paraphrase:
CO_2-emissions will be cut or there will be more floods.
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It's not the case that CO_2-emissions will be cut.

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It's not the case that CO_2-emissions will be cut.
Formalisation: $\boldsymbol{\neg C}$.

C **Formalisation**: $\boldsymbol{M}$.

It remains to show.

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You know two ways to do this.

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Backwards truth-table

C	M	$(C \vee M)$	$\neg\, C$	M

It remains to show.

$$(C \vee M), \neg C \models M$$

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It remains to show.

$$(C \vee M), \neg C \models M$$

You know two ways to do this.

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This shows there cannot be a line in the truth-table in which both premisses are true and the conclusion is false.

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This shows there cannot be a line in the truth-table in which both premisses are true and the conclusion is false.
So, the English argument is propositionally valid.

http://logicmanual.philosophy.ox.ac.uk