Translation into SL

PHIL 500

September 11th, 2019

Validity and Formal Validity

An argument is *valid* if and only if it is impossible for its premises to be true while its conclusion is false.

An argument form is *valid* if and only if there is no substitution instance of the argument form which has all true premises and a false conclusion.

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- The problem: English is messy and complicated
- The plan: introduce a formal language (SL) which is less messy and less complicated.
  - ▹ SL will allow us to think about the validity of (some) *argument forms*

Outline

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Some common statement forms

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If $\mathscr{A}$, then $\mathscr{B}$	$(\mathscr{A} \rightarrow \mathscr{B})$

Symbolization: Logical Operators

It is not the case that $\mathscr{A}$	$\neg\mathscr{A}$
Both $\mathscr{A}$ and $\mathscr{B}$	$(\mathscr{A} \land \mathscr{B})$
Either $\mathscr{A}$ or $\mathscr{B}$	$(\mathscr{A} \lor \mathscr{B})$
If $\mathscr{A}$, then $\mathscr{B}$	$(\mathscr{A} \rightarrow \mathscr{B})$
$\mathscr{A}$ if and only if $\mathscr{B}$	$(\mathscr{A} \leftrightarrow \mathscr{B})$

Atomic Statements

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  - E.g., we may use '*A*' for 'Albino rhinos throw dough in the rodeo'
  - And we may use '*B*' for 'Bold marigolds got a foothold in the old scaffold.'

Symbolization

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N : Nobody knows the trouble I've seen

A : Ants ate my car keys

S : Santa Claus exists

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▹ $\neg S$

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- ▹ $\neg S$
- ▹ $(N \wedge A)$

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Symbolization

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$$\begin{aligned} N &: \quad \text{Nobody knows the trouble I've seen} \\ A &: \quad \text{Ants ate my car keys} \\ S &: \quad \text{Santa Claus exists} \end{aligned}$$

- ▹ $\neg S$
- ▹ $(N \wedge A)$
- ▹ $(\neg A \rightarrow S)$
- ▹ $\neg(A \vee S)$

Statement letters and statement variables

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- 'A' and 'B' are *statement letters*. They represent a *particular* statement.
  - The symbolization key tells us which statements letters like 'A' and 'B' represent.

Outline

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Negation

- In SL, a sentence of the form '$\neg\mathscr{A}$' is a *negation*.

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- '$\neg\mathscr{A}$' means 'It is not the case that $\mathscr{A}$'.

Negation

- Symbolization key:

$$A: \text{Abelard loves Heloise}$$

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$$A: \text{Abelard loves Heloise}$$

  - English: 'Abelard doesn't love Heloise'

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- ▹ English: 'Abelard doesn't love Heloise'
- ▹ English: 'It is not the case that Abelard loves Heloise'

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▹ English: 'Abelard doesn't love Heloise'

▹ English: 'It is not the case that Abelard loves Heloise'

▹ SL: '$\neg A$'

Negation

- Symbolization key:

$$G: \text{I believe God exists}$$

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- Symbolization key:

$$G : \text{I believe God exists}$$

  - English: 'I believe God doesn't exist'

Negation

- Symbolization key:

$$G : \text{I believe God exists}$$

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Negation

- Symbolization key:

$$G: \text{I believe God exists}$$

▹ English: 'I believe God doesn't exist'

▹ SL: '$\neg G$' ?

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- Symbolization key:

$$G: \text{I believe God exists}$$

- ▹ English: 'I believe God doesn't exist'
- ▹ SL: '$\neg G$' ?
- ▹ No

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- In SL, a sentence of the form ‘$(\mathscr{A} \wedge \mathscr{B})$’ is a *conjunction*.
  - In this sentence, ‘$\mathscr{A}$’ and ‘$\mathscr{B}$’ are called *conjuncts*.
- ‘$(\mathscr{A} \wedge \mathscr{B})$’ means ‘Both $\mathscr{A}$ and $\mathscr{B}$’.

Conjunction

- Symbolization key:

$$A: \text{Abelard loves Heloise}$$
$$H: \text{Heloise loves Abelard}$$

Conjunction

- Symbolization key:

$$A: \text{Abelard loves Heloise}$$
$$H: \text{Heloise loves Abelard}$$

▹ English: 'Abelard loves Heloise and Heloise doesn't love Abelard'

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- Symbolization key:

$$A: \text{Abelard loves Heloise}$$
$$H: \text{Heloise loves Abelard}$$

▹ English: 'Abelard loves Heloise and Heloise doesn't love Abelard'

▹ SL: '$(A \wedge \neg H)$'

Conjunction

- Symbolization key:

$$\begin{aligned} A &: \text{Abelard loves Heloise} \\ H &: \text{Heloise loves Abelard} \end{aligned}$$

Conjunction

- Symbolization key:

$$A: \text{Abelard loves Heloise}$$
$$H: \text{Heloise loves Abelard}$$

▹ English: 'Abelard loves Heloise, but Heloise doesn't love Abelard'

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- Symbolization key:

$$A: \text{Abelard loves Heloise}$$
$$H: \text{Heloise loves Abelard}$$

▹ English: 'Abelard loves Heloise, but Heloise doesn't love Abelard'

▹ SL: '$(A \wedge \neg H)$'

Conjunction

$$\left.\begin{array}{c} \mathscr{A} \text{ and } \mathscr{B} \\ \mathscr{A}\text{, but } \mathscr{B} \\ \mathscr{A}\text{; however, } \mathscr{B} \\ \mathscr{A}\text{, though } \mathscr{B} \\ \mathscr{A} \text{ as well as } \mathscr{B} \end{array}\right\} \rightarrow (\mathscr{A} \land \mathscr{B})$$

Conjunction

- Symbolization key:

$$A: \text{Adam will go to the party}$$
$$B: \text{Betsy will go to the party}$$

Conjunction

- Symbolization key:

$$A : \text{Adam will go to the party}$$
$$B : \text{Betsy will go to the party}$$

▹ English: 'Adam and Betsy won't both go to the party'

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- Symbolization key:

$$A: \text{Adam will go to the party}$$
$$B: \text{Betsy will go to the party}$$

▹ English: 'Adam and Betsy won't both go to the party'

▹ SL: '$\neg(A \land B)$'

Conjunction

- Symbolization key:

$$A: \text{ Adam will go to the party}$$
$$B: \text{ Betsy will go to the party}$$

- ▹ English: 'Adam and Betsy both won't go to the party'
- ▹ SL: '$\neg(A \wedge B)$'

Conjunction

- Symbolization key:

$$A: \text{ Adam will go to the party}$$
$$B: \text{ Betsy will go to the party}$$

  - ▹ English: 'Adam and Betsy both won't go to the party'
  - ▹ SL: '$(\neg A \wedge \neg B)$'

Outline

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  - In this sentence, ‘$\mathscr{A}$’ and ‘$\mathscr{B}$’ are called *disjuncts*.
- ‘$(\mathscr{A} \vee \mathscr{B})$’ means ‘Either $\mathscr{A}$ or $\mathscr{B}$’.

Disjunction

Inclusive 'or'

If 'or' is *inclusive*, then 'Either $\mathscr{A}$ or $\mathscr{B}$' is true when both '$\mathscr{A}$' and '$\mathscr{B}$' are true.

Exclusive 'or'

If 'or' is *exclusive*, then 'Either $\mathscr{A}$ or $\mathscr{B}$' is false when both '$\mathscr{A}$' and '$\mathscr{B}$' are true.

Disjunction

- Exclusive ‘or’: ‘Either you clean your room or you’re grounded’

Disjunction

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- Inclusive ‘or’: ‘Either Adam or Betsy could lift that’

Disjunction

- In SL, '$(\mathscr{A} \vee \mathscr{B})$' translates the *inclusive* 'or'.

Disjunction

- In SL, ‘$(\mathscr{A} \vee \mathscr{B})$’ translates the *inclusive* ‘or’.
- In this class, *whenever* we say ‘or’, we mean the *inclusive* ‘or’.

Disjunction

- Symbolization key:

$$B: \text{Tamara bought a bicycle}$$
$$M: \text{Tamara bought a motorcycle}$$

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- Symbolization key:

$$B: \text{Tamara bought a bicycle}$$
$$M: \text{Tamara bought a motorcycle}$$

  - English: ‘Tamara bought either a bicycle or a motorcycle’

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  ▹ English: 'Tamara bought neither a bicycle nor a motorcycle'
  ▹ SL: '$(B \vee M)$'

Disjunction

- Symbolization key:

$$B: \text{Tamara bought a bicycle}$$
$$M: \text{Tamara bought a motorcycle}$$

  - English: 'Tamara bought neither a bicycle nor a motorcycle'
  - SL: '$\neg(B \vee M)$'

Disjunction

- Symbolization key:

$$B: \text{Tamara bought a bicycle}$$
$$M: \text{Tamara bought a motorcycle}$$

  - English: ‘Tamara bought neither a bicycle nor a motorcycle’
  - SL: ‘$(\neg B \wedge \neg M)$’

Disjunction

- Symbolization key:

$$C: \text{Craig will go sailing on Monday}$$
$$R: \text{It rains on Monday}$$

Disjunction

- Symbolization key:

$$C: \text{Craig will go sailing on Monday}$$
$$R: \text{It rains on Monday}$$

▹ English: ‘Craig will go sailing on Monday, unless it rains’

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Disjunction

$$\left.\begin{array}{c}\text{Either } \mathscr{A} \text{ or } \mathscr{B} \\ \mathscr{A} \text{ unless } \mathscr{B}\end{array}\right\} \longrightarrow (\mathscr{A} \vee \mathscr{B})$$

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$$\text{Neither } \mathscr{A} \text{ nor } \mathscr{B} \;\Big\} \longrightarrow \neg(\mathscr{A} \vee \mathscr{B})$$

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- In SL, a sentence of the form '$(\mathscr{A} \rightarrow \mathscr{B})$' is a *conditional*.
  - ▹ In '$(\mathscr{A} \rightarrow \mathscr{B})$', '$\mathscr{A}$' is called the *antecedent*
  - ▹ In '$(\mathscr{A} \rightarrow \mathscr{B})$', '$\mathscr{B}$' is called the *consequent*
- '$(\mathscr{A} \rightarrow \mathscr{B})$' means 'If $\mathscr{A}$, then $\mathscr{B}$'.

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▹ English: 'If Adam goes to the party, then Betsy will, too.'

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$$A: \text{Adam will go to the party}$$
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  - English: ‘If Adam goes to the party, then Betsy will, too.’
  - SL: ‘$(A \rightarrow B)$’

Conditional

- Symbolization key:

$$A: \text{ Adam will go to the party}$$
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- ▹ English: 'Adam will go to the party only if Betsy does, too'
- ▹ SL:

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Conditional

$$\left.\begin{array}{c}\text{If } \mathscr{A}\text{, then } \mathscr{B} \\ \mathscr{A} \text{ only if } \mathscr{B} \\ \mathscr{B} \text{ if } \mathscr{A}\end{array}\right\} \to (\mathscr{A} \to \mathscr{B})$$

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Biconditional

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- ‘$(\mathscr{A} \leftrightarrow \mathscr{B})$’ means ‘$\mathscr{A}$ if and only if $\mathscr{B}$’.

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- In SL, a sentence of the form '$(\mathscr{A} \leftrightarrow \mathscr{B})$' is a *biconditional*.
  - ▹ In '$(\mathscr{A} \leftrightarrow \mathscr{B})$', '$\mathscr{A}$' is called the *left-hand-side*
  - ▹ In '$(\mathscr{A} \leftrightarrow \mathscr{B})$', '$\mathscr{B}$' is called the *right-hand-side*
- '$(\mathscr{A} \leftrightarrow \mathscr{B})$' means '$\mathscr{A}$ if and only if $\mathscr{B}$'.
  - ▹ We will see that it means the same thing as '$((\mathscr{A} \rightarrow \mathscr{B}) \wedge (\mathscr{B} \rightarrow \mathscr{A}))$'.

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  - ▹ SL: '$(S \leftrightarrow R)$'

Biconditional

- Symbolization key:

$$R: \text{Rusty runs for Mayor}$$
$$S: \text{Sandy votes for Teddy}$$

  - English: 'Sandy will vote for Teddy if and only if Rusty doesn't run for Mayor.'
  - SL: '$(S \leftrightarrow \neg R)$'

Biconditional

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Outline

Canonical Logical Expressions

- It is not the case that $\mathscr{A}$
- Both $\mathscr{A}$ and $\mathscr{B}$
- Either $\mathscr{A}$ or $\mathscr{B}$
- If $\mathscr{A}$, then $\mathscr{B}$
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- English: '*If both John loves Andrew and it is not the case that Andrew loves John, then it is not the case that John and Andrew will be friends*.'
- Let $J =$ 'John loves Andrew', $A =$ Andrew loves John, and $F =$ 'John and Andrew will be friends'. Then, in SL:

$$((J \wedge \neg A) \rightarrow \neg F)$$

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Translation into SL

- *John and Andrew won't be friends if John loves Andrew but Andrew doesn't love him back*

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- *If John loves Andrew but Andrew doesn't love him back, John and Andrew won't be friends*

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- *If both John loves Andrew and Andrew doesn't love John, then John and Andrew won't be friends*
- *If both John loves Andrew and it is not the case that Andrew loves John, then it is not the case that John and Andrew will be friends.*

Translation into SL

- *John and Andrew won't be friends if John loves Andrew but Andrew doesn't love him back*
- *If John loves Andrew but Andrew doesn't love him back, John and Andrew won't be friends*
- *If both John loves Andrew and Andrew doesn't love John, then John and Andrew won't be friends*
- *If both John loves Andrew and it is not the case that Andrew loves John, then it is not the case that John and Andrew will be friends.*
- $((J \wedge \neg A) \rightarrow \neg F)$

Translation into SL

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- A general strategy:
  - To translate a sentence of English into SL, find another sentence of English which is synonymous with the first, and which is in *canonical logical form*.
  - Then, translate the sentence into SL using the translation guide:

$$
\begin{array}{lcl}
\text{It is not the case that } \mathscr{A} & \mapsto & \neg\mathscr{A} \\
\text{Both } \mathscr{A} \text{ and } \mathscr{B} & \mapsto & (\mathscr{A} \wedge \mathscr{B}) \\
\text{Either } \mathscr{A} \text{ or } \mathscr{B} & \mapsto & (\mathscr{A} \vee \mathscr{B}) \\
\text{If } \mathscr{A}\text{, then } \mathscr{B} & \mapsto & (\mathscr{A} \rightarrow \mathscr{B}) \\
\mathscr{A} \text{ if and only if } \mathscr{B} & \mapsto & (\mathscr{A} \leftrightarrow \mathscr{B})
\end{array}
$$

Translation into SL

- *I won't go if John does*

Translation into SL

- *I won't go if John does*
- *If John goes, then I won't go*

Translation into SL

- *I won't go if John does*
- *If John goes, then I won't go*
- *If John goes, then it is not the case that I go*

Translation into SL

- *I won't go if John does*
- *If John goes, then I won't go*
- *If John goes, then it is not the case that I go*
- *(John goes → it is not the case that I go)*

Translation into SL

- *I won't go if John does*
- *If John goes, then I won't go*
- *If John goes, then it is not the case that I go*
- *(John goes $\longrightarrow$ it is not the case that I go)*
- *(John goes $\longrightarrow$ $\neg$ I go)*

Translation into SL

- *I won't go if John does*
- *If John goes, then I won't go*
- *If John goes, then it is not the case that I go*
- *(John goes $\rightarrow$ it is not the case that I go)*
- *(John goes $\rightarrow$ $\neg$ I go)*
- $(J \rightarrow \neg I)$

Translation into SL

- *I won't go if John does*
- *If John goes, then I won't go*
- *If John goes, then it is not the case that I go*
- *(John goes* $\rightarrow$ *it is not the case that I go)*
- *(John goes* $\rightarrow$ $\neg$ *I go)*
- $(J \rightarrow \neg I)$

Translation into SL

- *I hate getting what I want and I hate not getting what I want*

Translation into SL

- *I hate getting what I want and I hate not getting what I want*
- *Both I hate getting what I want and it is not the case that I hate getting what I want*

Translation into SL

- *I hate getting what I want and I hate not getting what I want*
- *Both I hate getting what I want and it is not the case that I hate getting what I want*
- *(I hate getting what I want* $\wedge$ *it is not the case that I hate getting what I want)*

Translation into SL

- *I hate getting what I want and I hate not getting what I want*
- *Both I hate getting what I want and it is not the case that I hate getting what I want*
- *(I hate getting what I want* $\wedge$ *it is not the case that I hate getting what I want)*
- *(I hate getting what I want* $\wedge\neg$ *I hate getting what I want)*

Translation into SL

- *I hate getting what I want and I hate not getting what I want*
- *Both I hate getting what I want and it is not the case that I hate getting what I want*
- *(I hate getting what I want* ∧ *it is not the case that I hate getting what I want)*
- *(I hate getting what I want* ∧¬ *I hate getting what I want)*
- $(H \wedge \neg H)$

Translation into SL

- *I hate getting what I want and I hate not getting what I want*
- *Both I hate getting what I want and it is not the case that I hate getting what I want*
- *(I hate getting what I want* $\wedge$ *it is not the case that I hate getting what I want)*
- *(I hate getting what I want* $\wedge \neg$ *I hate getting what I want)*
- $(H \wedge \neg H)$

- Oh no! We started off with a truth and ended up with a necessary falsehood. Where did we go wrong?