DIALOGUE MODELING IN A DYNAMIC FRAMEWORK

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A simple dialogue

A_1 Charlie is a unicorn.

A simple dialogue

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➔ Semantics: compositionality

A simple dialogue

A_1 Charlie is a unicorn.

B_2 She prefers coffee or tea?

➔ Semantics: compositionality

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A_1 Charlie is a unicorn.

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➔ Context: dynamicity

A simple dialogue

A_1 Charlie is a unicorn.

B_2 She prefers coffee or tea?

A_3 Yes.

➔ Semantics: compositionality

➔ Context: dynamicity

A simple dialogue

A_1 Charlie is a unicorn.

B_2 She prefers coffee or tea?

A_3 Yes.

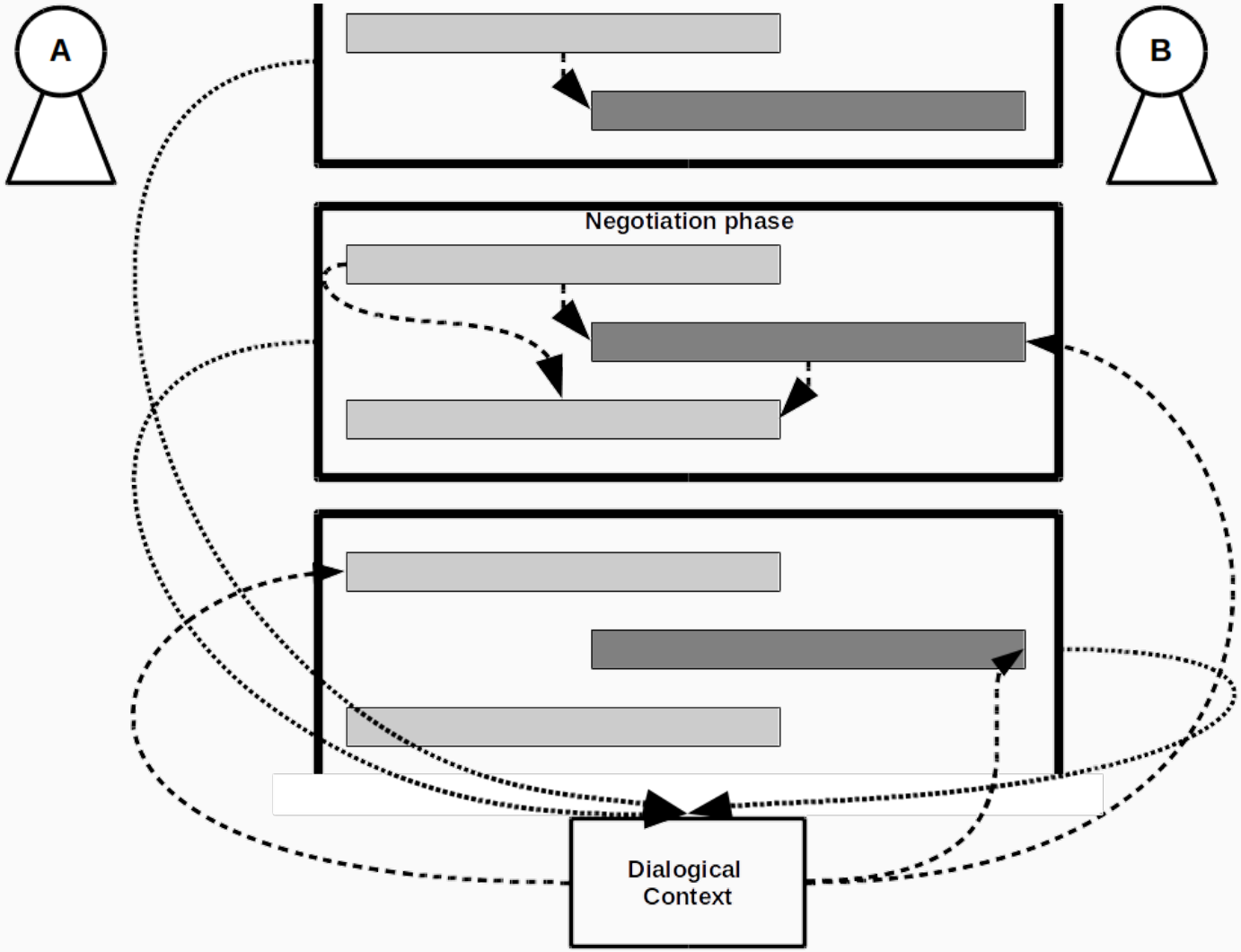
➔ Semantics: compositionality

➔ Context: dynamicity

➔ Coherence: logic

Negotiation phases

Picturing questions and answers – a formal approach to SLAM, Maria Boritchev, Maxime Amblard, (In)coherence of discourse – Formal and Conceptual issues of Language, Springer, 2021.



Questions and answers in dialogue

Example (Simple answer, Strategic Conversation Corpus, [Asher et al., 2016])

tomas.kostan is the game on tonight?

ljaybrad123 yes it is

Questions and answers in dialogue

Example (Complex answer, Saarbrücken Corpus of Spoken English, [Norrick, 2017])

Neal did you see any of the great conductors?

Albertine well, I'll tell you what ah ...

there was ah-...opera there- that was

but anyway, there is an Afro-American who did the ...

who did that part so BEAUTIfully.

Our (ideal) aim

We want to:

- Produce formal models for semantics of natural languages (**logical, compositional, dynamic**)
- Produce formal models for semantics of dialogue (**negotiation phases**)
- That would behave well on non-controlled data (**lexicality, flexibility**)

Towards:

➔ Development of more realistic chatbots

➔ Hybrid approaches: combining machine learning techniques and logic representations

➔ Dialogue studies: clinical applications

Outline

Dialogue annotation

Formal semantics of dialogue

DIALOGUE ANNOTATION

Annotation schema

Toward Dialogue Modeling: A Semantic Annotation Scheme for Questions and Answers, Maria-Andrea Cruz-Blandón, Gosse Minnema, Aria Nourbakhsh, Maria Boritchev, Maxime Amblard, LAW XIII 2019 – The 13th Linguistic Annotation Workshop, 2019.

Tag	Name
YN	yes/no-question
WH	wh-question
DQ	disjunctive question
CS	completion suggestion
PQ	phatic question

Table: Set of question tags.

History of development

English Saarbrücken Corpus of Spoken English (SCoSE), corpus of face-to-face conversations

Spanish CallFriend corpus for Spanish, corpus of phone conversations

Dutch Spoken Dutch Corpus (CGN), corpus of phone conversations

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	YN	WH	DQ	CS	PQ
SCoSE	42.2%	23.5%	1.2%	1.7%	31.5%
CallFriend	39.9%	33.0%	1.6%	1.1%	24.5%
CGN	64.4%	26.4%	1.2%	0%	8.1%

Table: Statistic distribution of question tags (in percentage) across English, Spanish, and Dutch corpora.

FORMAL SEMANTICS OF DIALOGUE

Few existing works in formal semantics of NL

MS Montague semantics, [Montague, 1973]

CSDS Compositional Style Dynamic Semantics, [de Groote, 2006]

NDES Neo-Davidsonian Event Semantics, [Parsons, 1995],
Quantificational Event Semantics [Champollion, 2011],
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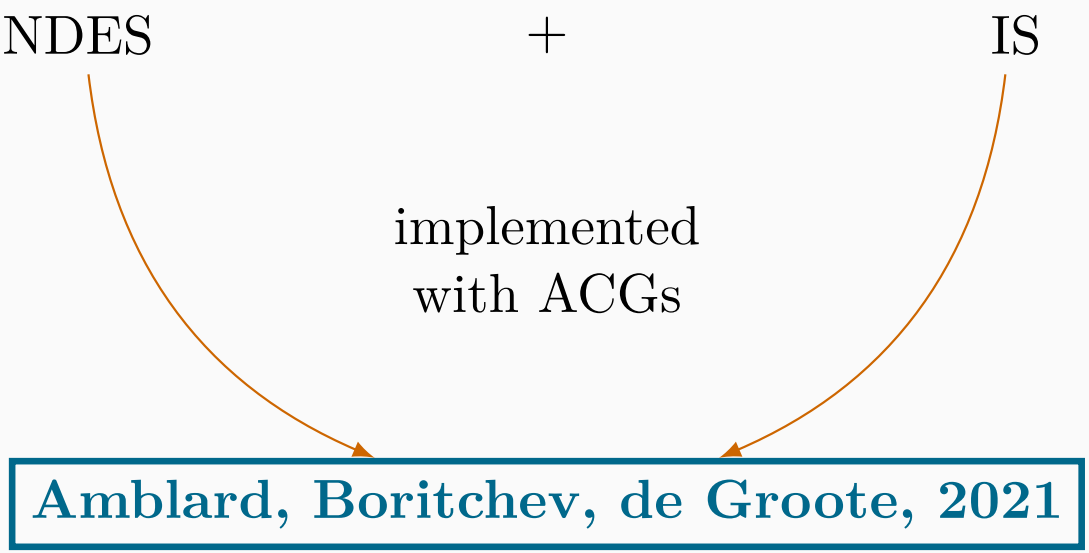
➔ Declarative and interrogative sentences

Family photo



Neo-Davidsonian Event Semantics (NDES)

every farmer fed a donkey

Neo-Davidsonian Event Semantics (NDES)

every farmer fed a donkey

event

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Agent event Patient

$$\forall x.\exists y.\exists e.\text{fed}(e) \wedge \text{farmer}(x) \wedge \text{donkey}(y) \wedge \text{Agent}(e, x) \wedge \text{Patient}(e, y)$$

Questions?

$$\forall x.\exists y.\exists e.\text{fed}(e) \wedge \text{farmer}(x) \wedge \text{donkey}(y) \wedge \textbf{Agent}(e, x) \wedge \textbf{Patient}(e, y)$$

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Who fed a donkey?

Whom did every farmer feed?

Questions?

$$\forall x.\exists y.\exists e.\text{fed}(e) \wedge \text{farmer}(x) \wedge \text{donkey}(y) \wedge \textbf{Agent}(e, x) \wedge \textbf{Patient}(e, y)$$

Who fed a donkey?

Whom did every farmer feed?

Which is the agent of the feeding event whose patient is a donkey?

Which is the patient of the feeding event whose agent is every farmer?

In perspective

- NDES is compositional.
- We can interrogate the content of thematic roles.
- How to compute the semantic representation of interrogative sentences?

Donkey (D)

Unicorn (U)

Inquisitive semantics

Donkey (D)

Unicorn (U)

Are they hungry?

Donkey (D) Unicorn (U)

Are they hungry?

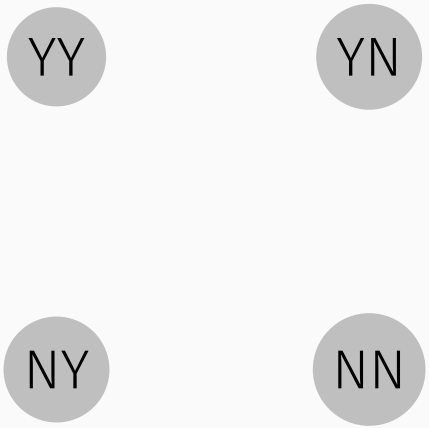

Figure: Possible worlds

$$[\![\text{D is hungry}]\!] = [\![\phi_1]\!] = \{\{\text{YY}, \text{YN}\}, \{\text{YY}\}, \{\text{YN}\}, \emptyset\}$$

Inquisitive semantics

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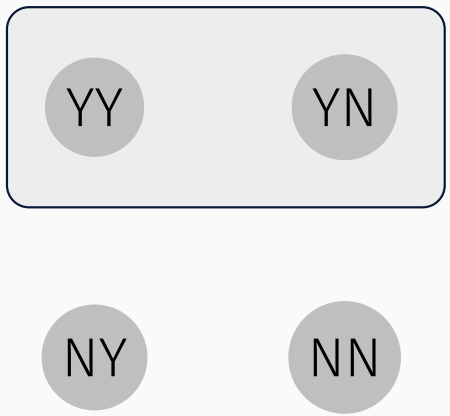
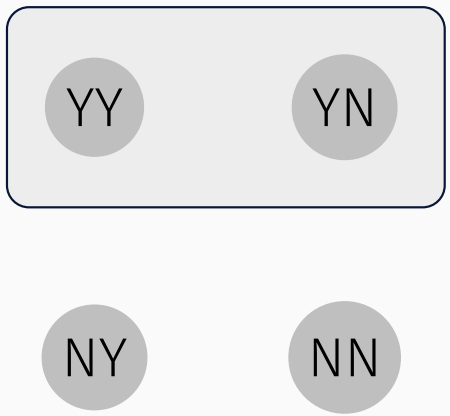


(a)

Inquisitive semantics

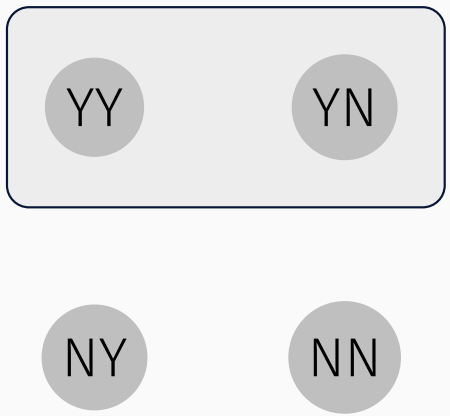
$$[\![\text{D is hungry}]\!] = [\![\phi_1]\!] = \{\{\text{YY}, \text{YN}\}, \{\text{YY}\}, \{\text{YN}\}, \emptyset\}$$
$$[\![\text{U is hungry}]\!] = [\![\phi_2]\!] = \{\{\text{YY}, \text{NY}\}, \{\text{YY}\}, \{\text{NY}\}, \emptyset\}$$



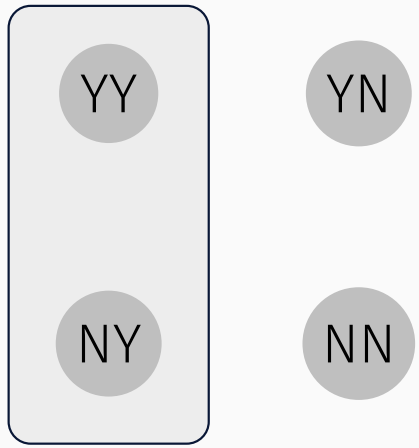
(a)

Inquisitive semantics

$$[\![\text{D is hungry}]\!] = [\![\phi_1]\!] = \{\{\text{YY}, \text{YN}\}, \{\text{YY}\}, \{\text{YN}\}, \emptyset\}$$
$$[\![\text{U is hungry}]\!] = [\![\phi_2]\!] = \{\{\text{YY}, \text{NY}\}, \{\text{YY}\}, \{\text{NY}\}, \emptyset\}$$



(a)



(b)

$$\begin{aligned}[\![\phi_1 \vee \phi_2]\!] &= [\![\phi_1]\!] \cup [\![\phi_2]\!] \\ &= \{\{\mathsf{YY}, \mathsf{YN}\}, \{\mathsf{YY}, \mathsf{NY}\}, \{\mathsf{YY}\}, \{\mathsf{YN}\}, \{\mathsf{NY}\}, \emptyset\}\end{aligned}$$

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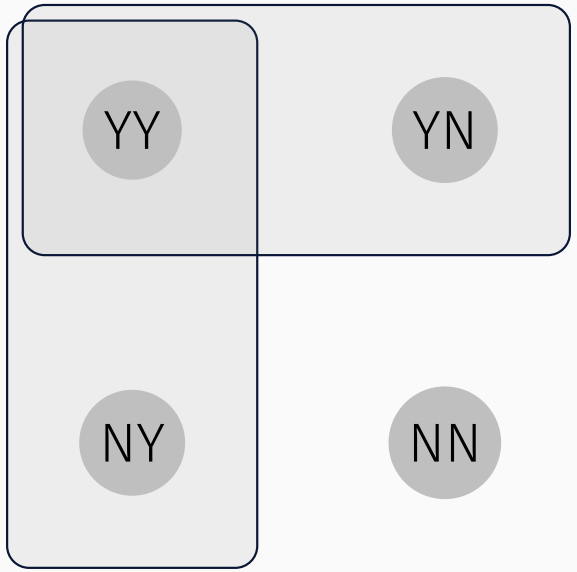

$$[\![\phi_1 \vee \phi_2]\!] = [\![\phi_1]\!] \cup [\![\phi_2]\!]$$
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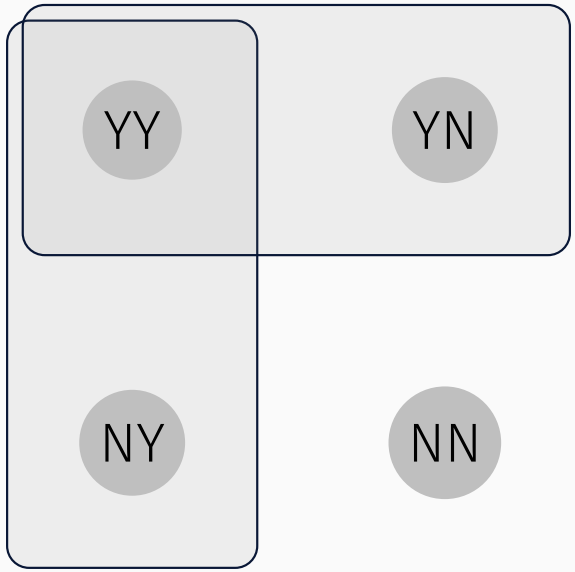
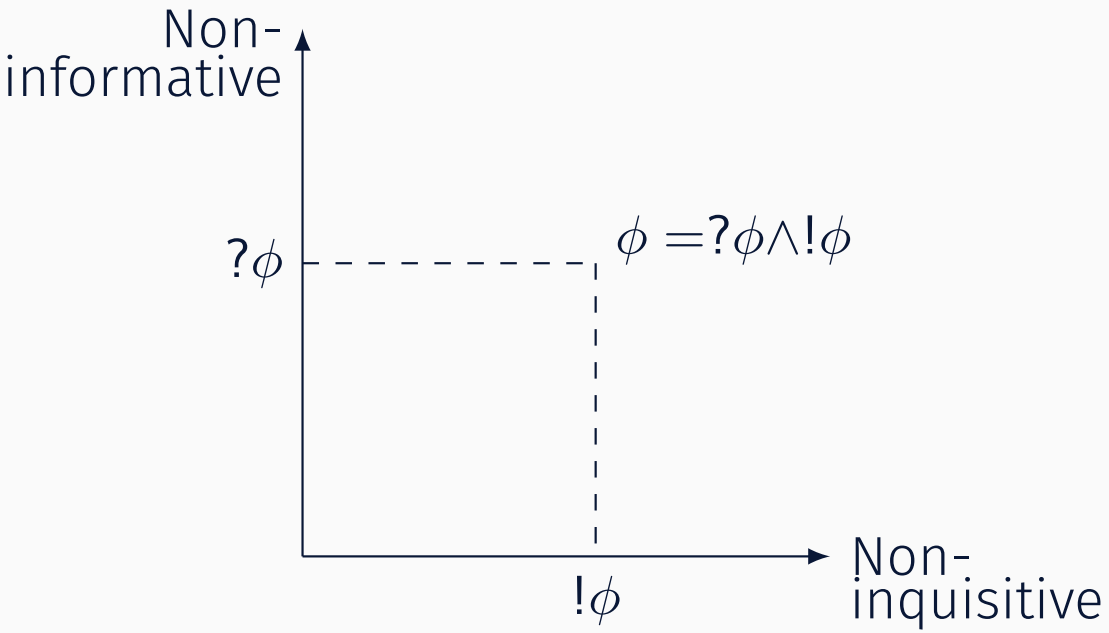


“is D or U hungry?” (knowing that someone is hungry)

Inquisitive semantics



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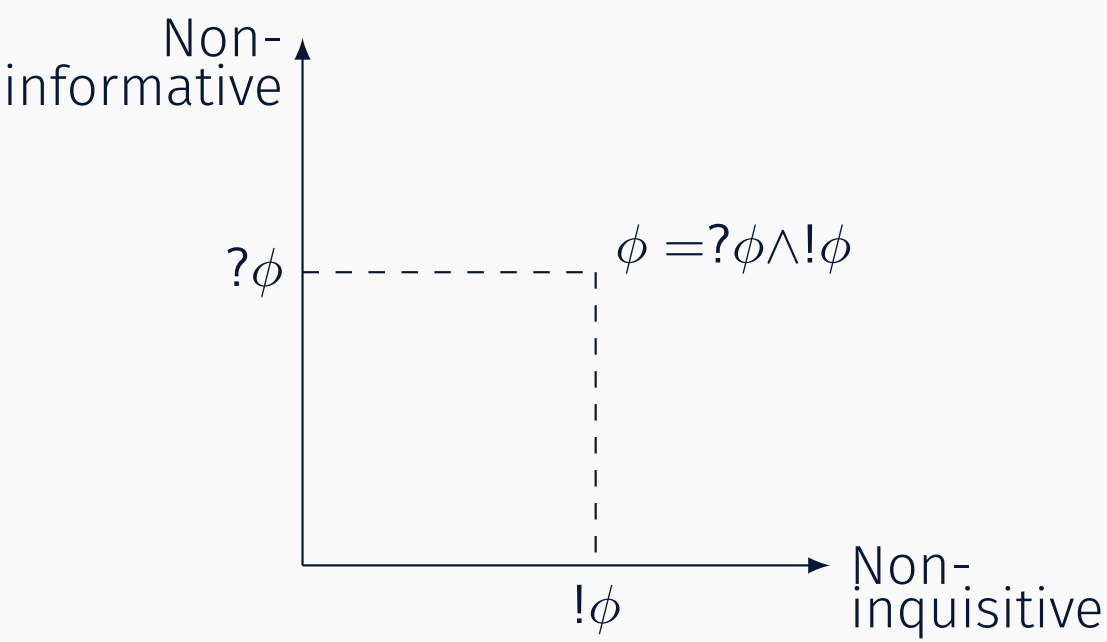
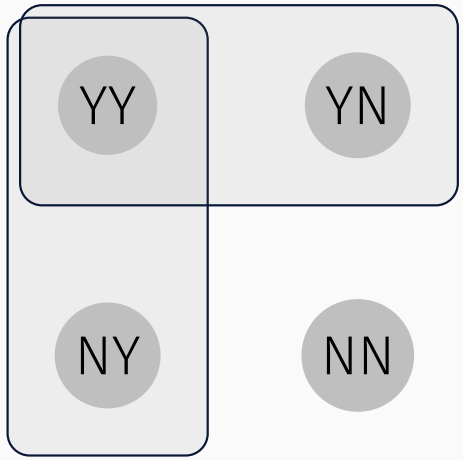
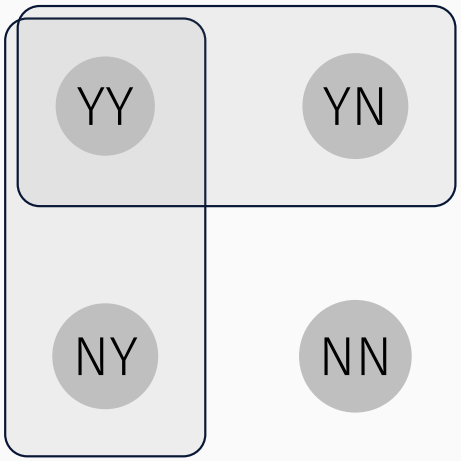




$[\![\phi_1 \vee \phi_2]\!]$

Inquisitive semantics



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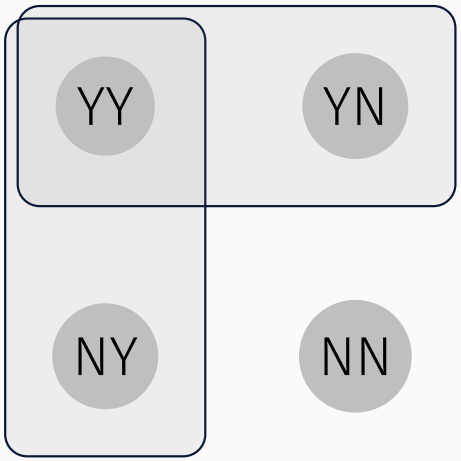

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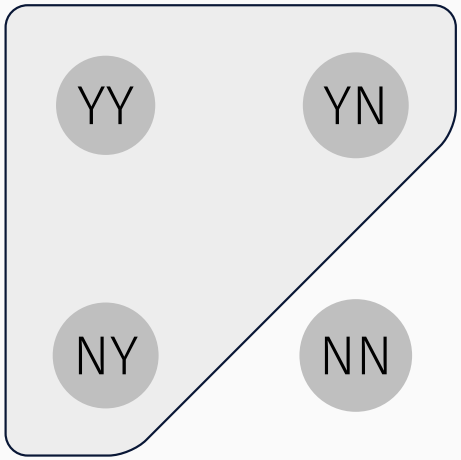

$[\![!(\phi_1 \vee \phi_2)]\!]$

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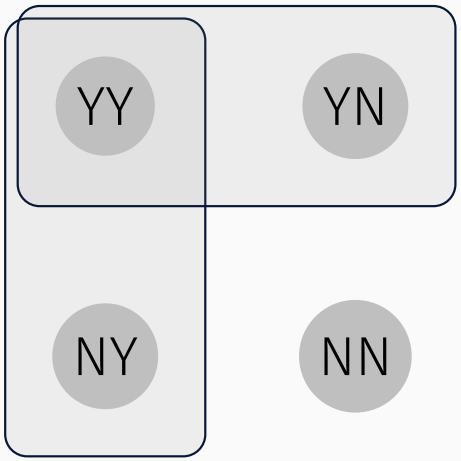

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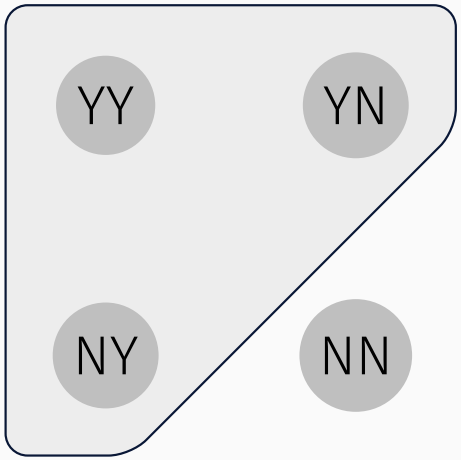

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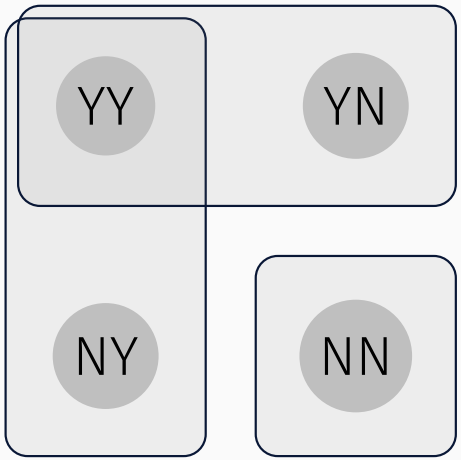

$[\![?(\phi_1 \vee \phi_2)]\!]$

Inquisitive semantics

In a model $\mathcal{M} = \langle D, W, I \rangle$, given a valuation ξ from $\mathcal{X}$ to D:

$$[\![\exists x.\phi]\!]_\xi = \bigcup_{d \in D} [\![\phi]\!]_{\xi[x:=d]}$$

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(1) ∃x.hungry x

(1) Somebody's hungry. Who?

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(3) ?$\exists$x.hungry x

(1) Somebody's hungry. Who?
(2) Somebody's hungry.
(3) Who is hungry?

In perspective

- NDES gives us access to thematic roles, through a unique wh-word WHICH

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Surface Forms

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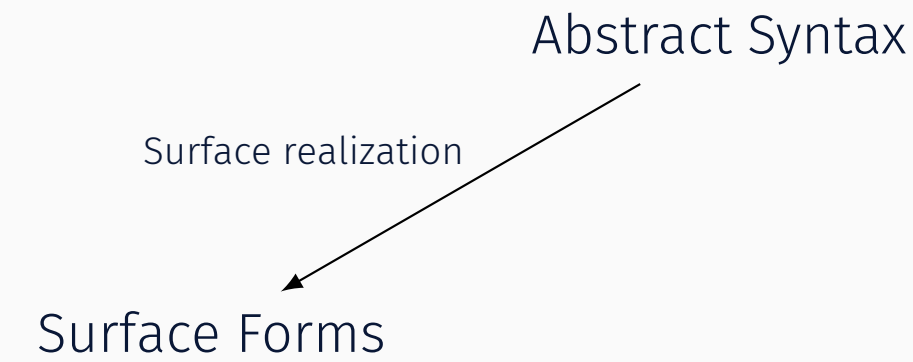

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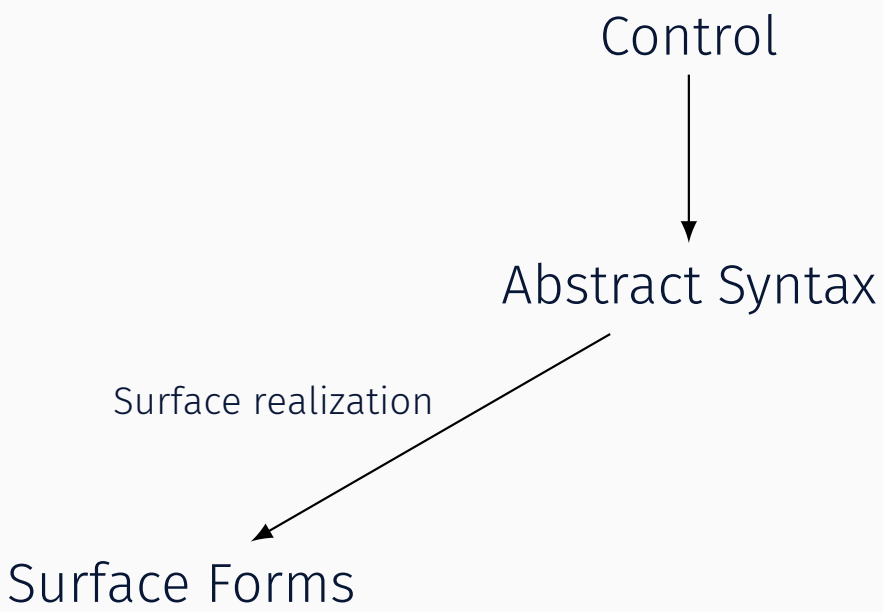

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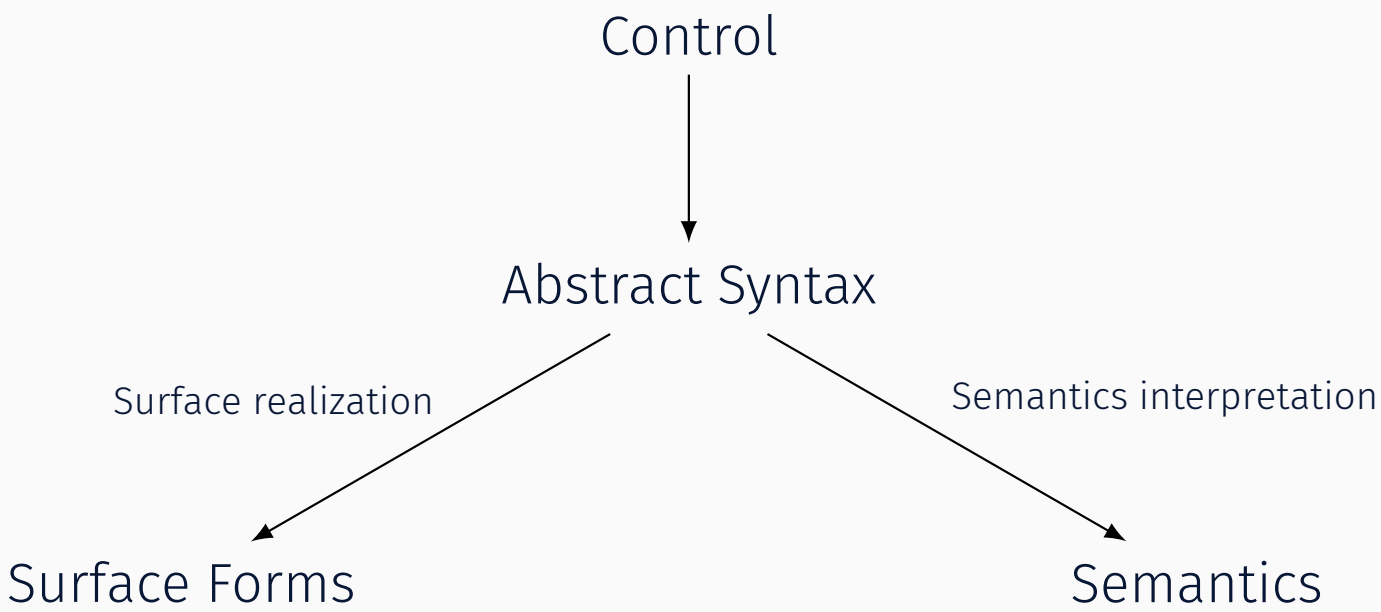
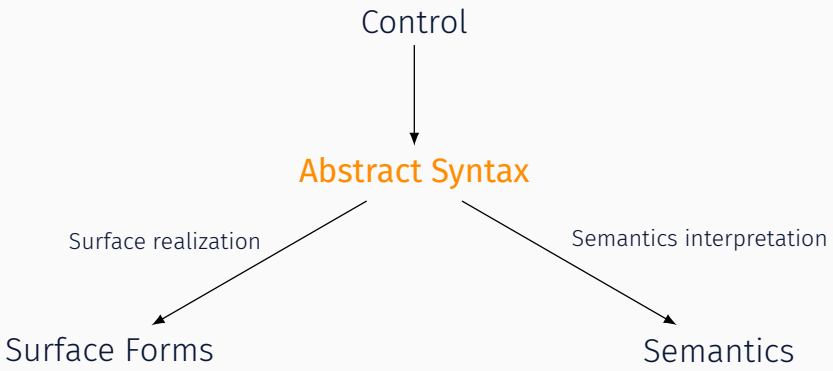


Excerpts from the grammar



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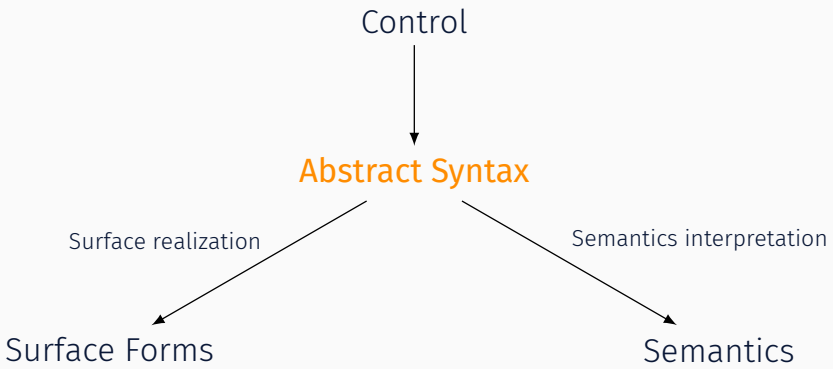
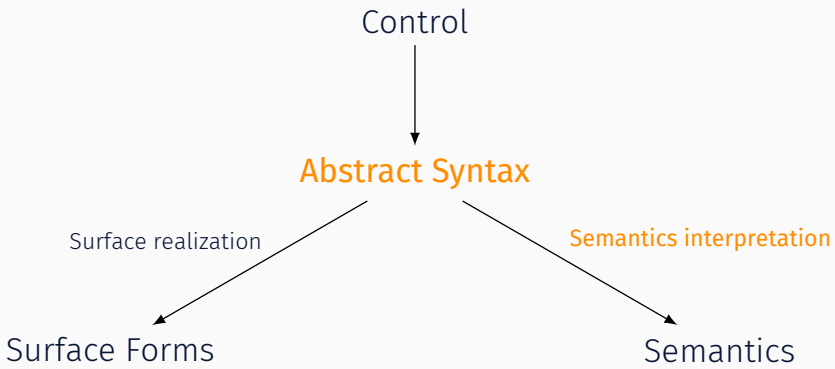


Abstract Syntax
$\textsc{some} : n \to (np \to s) \to s$
$\textsc{which} : n \to (np \to s) \to s$

Excerpts from the grammar



Abstract Syntax
$\textsc{some} : n \to (np \to s) \to s$
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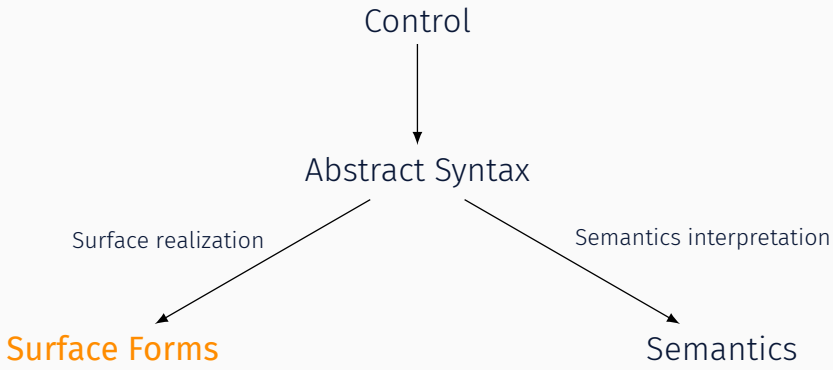
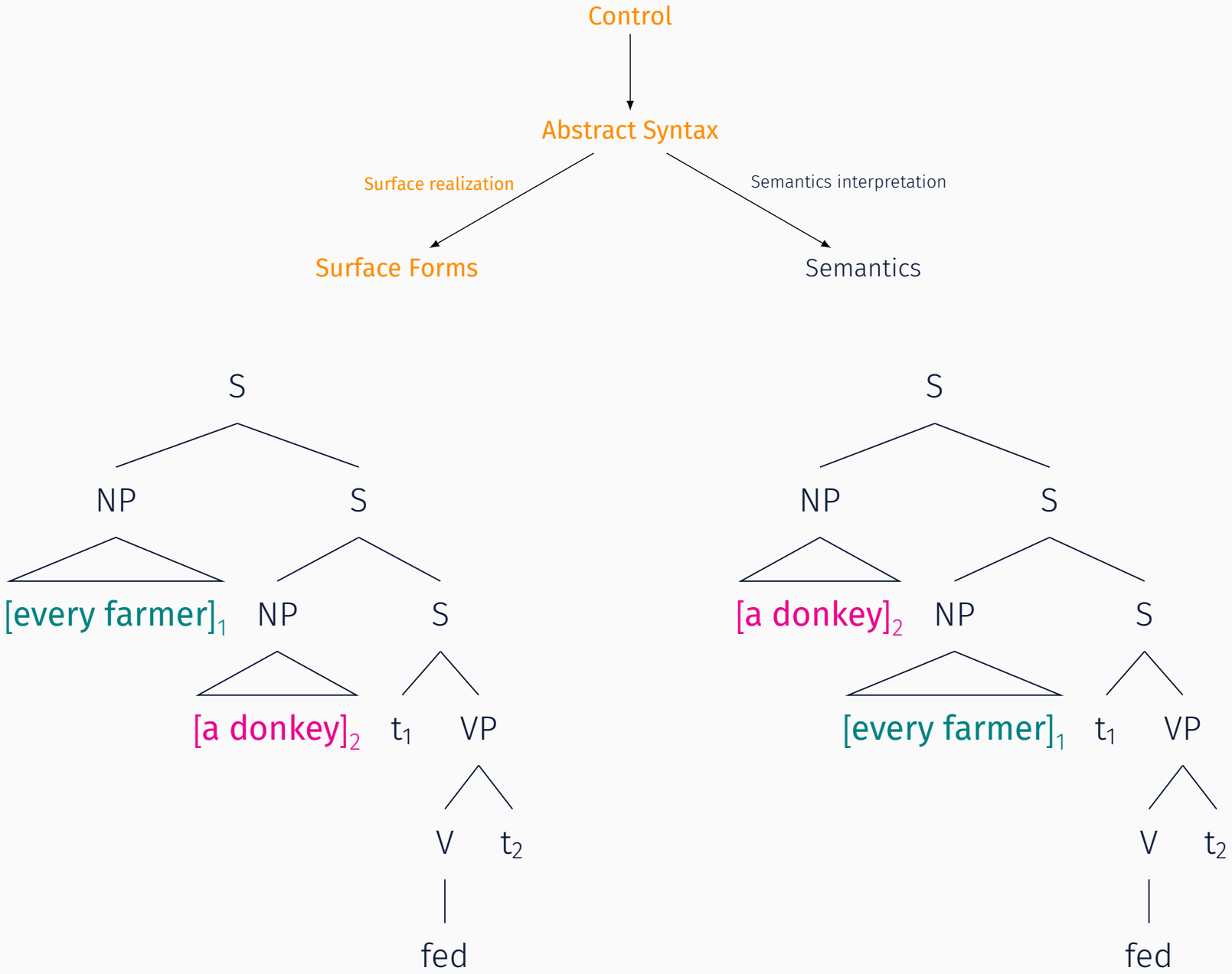
Semantic Interpretation
$\textsc{some} := \lambda pq.\, !(\exists x.\, (p\, x) \wedge (q\, x))$
$\textsc{which} := \lambda pq.\, \exists x.\, (p\, x) \wedge (q\, x)$

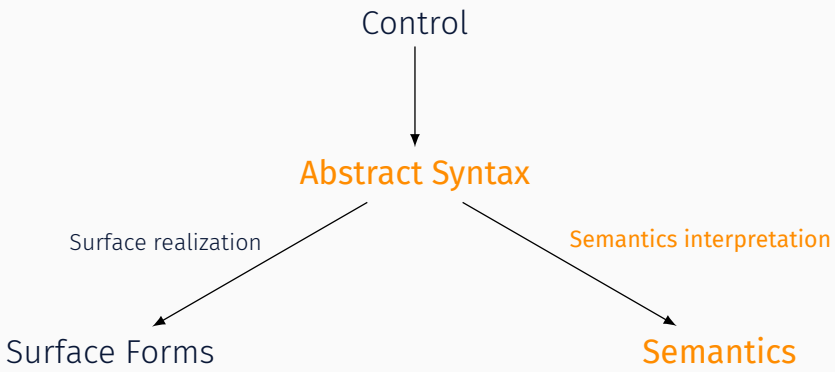


Every farmer fed a donkey

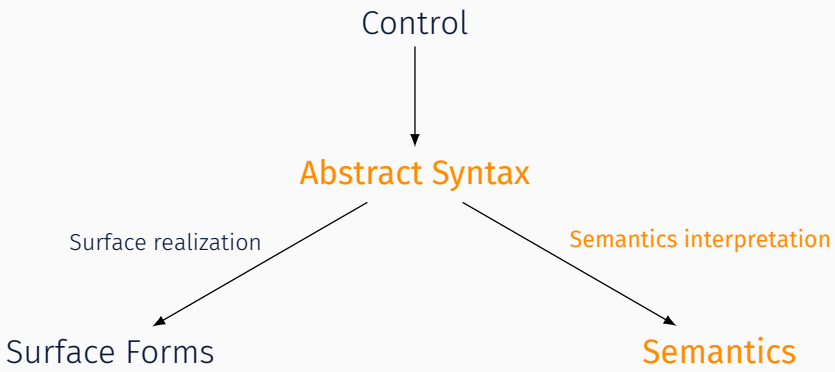


Every farmer fed a donkey

Where did every farmer feed a donkey?



Where did every farmer feed a donkey?



$$\text{Q}\,(\text{WHERE}\,(\lambda f.\ \textbf{EVERY FARMER}\,(\lambda x.\ \textbf{A DONKEY}\,(\lambda y.\ \text{E-CLOS}\,(f\,(\text{DID-FEED}\,y\,x)))))) \quad (1)$$

$$\text{Q}\,(\text{WHERE}\,(\lambda f.\ \textbf{A DONKEY}\ \ (\lambda x.\ \textbf{EVERY FARMER}\,(\lambda y.\ \text{E-CLOS}\,(f\,(\text{DID-FEED}\,x\,y)))))) \quad (2)$$

$$?\exists x.\forall y.(\text{farmer}\ y) \rightarrow !((\exists z.(\text{donkey}\ z) \wedge !((\exists e.(\text{fed}\ e) \wedge (\text{patient}\ e\ z) \wedge (\text{agent}\ e\ y) \wedge (\text{location}\ e\ x))))) \quad (1)$$

$$?\exists x.!(\exists y.(\text{donkey}\ y) \wedge (\forall z.(\text{farmer}\ z) \rightarrow !((\exists e.(\text{fed}\ e) \wedge (\text{patient}\ e\ y) \wedge (\text{agent}\ e\ z) \wedge (\text{location}\ e\ x))))) \quad (2)$$

Future work

➔ Other wh-words:

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whose how to represent the possessive relation? what is the corresponding thematic role?

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whose how to represent the possessive relation? what is the corresponding thematic role?

how “how long” VS “how far”

Future work

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what “what did the farmer do?”

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why EXPLANATION

Future work

➔ Other wh-words:

whose how to represent the possessive relation? what is the corresponding thematic role?

how "how long" VS "how far"

what "what did the farmer do?"

why EXPLANATION

➔ Integration in larger models of dialogue modeling

Conclusion

We have:

- Annotations of questions and answers in dialogue
- Formal models of semantics of dialogue

Now:

➔ Broadening and deepening of annotations

➔ Integration of our models in operationalized systems

➔ Hybrid approaches: combining machine learning techniques and logic representations

➔ Dialogue studies: clinical applications

Thank you for your attention!

Questions?

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