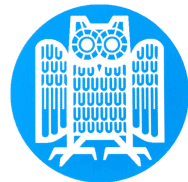


# Semantic Theory

## Introduction

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Saarland University  
Summer 2009



# Overview

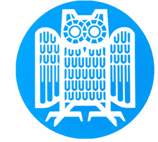
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- Inference in natural language; representing and processing meaning information in predicate logic
- Lexical semantics: Lexical-semantic resources; ontologies; Description Logic; Thematic roles; frames; event structure
- Sentence semantics: Montague-style type-theoretical representations; semantics construction; scope ambiguities; underspecification
- Discourse semantics: Anaphora; Discourse Representation Theory (DRT); presuppositions

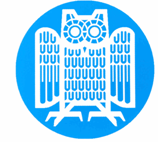
# Logical meaning representation

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- *Flipper is a dolphin*
- *Bill works*
- *Saarbrücken is fascinating*
- *Mary likes John*
- *John is taller than Bill*
- *John introduces Bill to Mary*
- *Saarbrücken is closer to Paris than Munich is to London*
- *Flipper is not a fish.*
- *Saarbrücken is a fascinating city.*

# Logical meaning representation



*Bill reads an interesting book.*

$\exists b (\text{book}(b) \wedge \text{interesting}(b) \wedge \text{read}(\text{bill}, b))$

*Dolphins are mammals, not fish.*

$\forall d (\text{dolphin}(d) \rightarrow \text{mammal}(d) \wedge \neg \text{fish}(d))$

*Dolphins live in pods.*

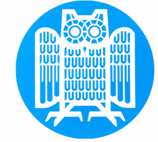
$\forall d (\text{dolphin}(d) \rightarrow \exists p (\text{pod}(p) \wedge \text{live-in}(d, p)))$

*Dolphins give birth to one baby at a time.*

$\forall d (\text{dolphin}(d) \rightarrow \forall x \forall y \forall t (\text{give-birth-to}(d, x, t) \wedge \text{give-birth-to}(d, y, t) \rightarrow x = y))$

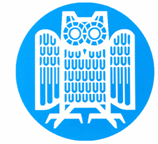
# Inference

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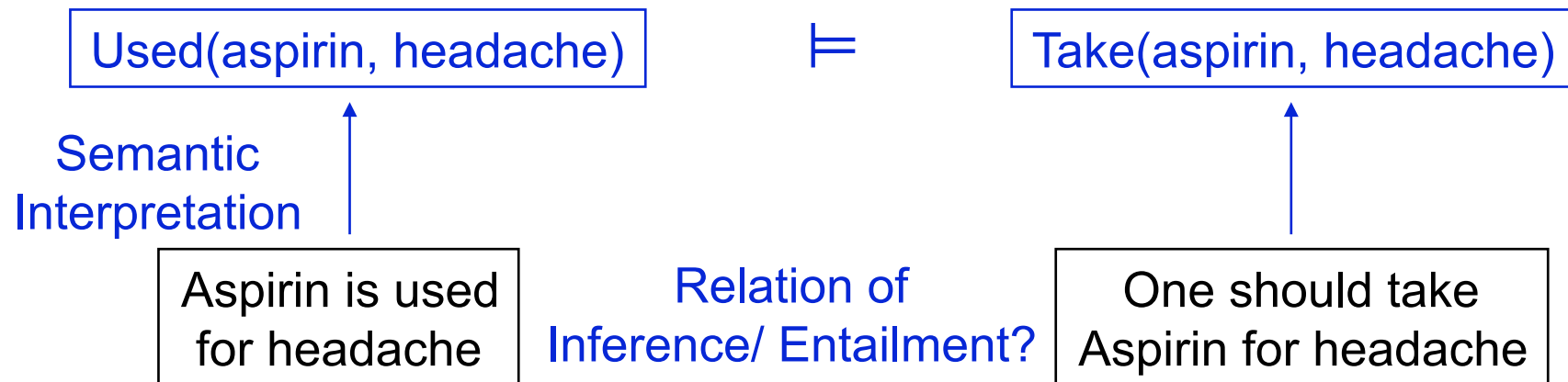


- Can I take Aspirin for headache?
- Aspirin is used for headache.
  
- Will there be classes on May 1?
- May 1 is a holiday.
  
- Should we meet at 11 a.m.?
- I have a class starting at 10.
  
- *Does Bill like lamb chops?*
- *Bill is a vegetarian.*

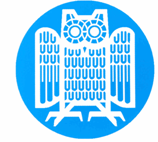
# Should I take Aspirin for headache?



Logical Entailment?



# Should I take Aspirin for headache?



Logical Entailment?

Computed through deduction systems/ theorem provers

$$\frac{\forall x \forall y (\text{used}(x,y) \rightarrow \text{take}(x,y)) \quad \text{used}(\text{aspirin}, \text{headache})}{\text{take}(\text{aspirin}, \text{headache})}$$

used(aspirin, headache)

$\models$

take(aspirin, headache)

Semantic Interpretation

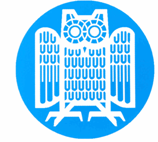
Aspirin is used for headache

Relation of Inference/ Entailment?

One should take Aspirin for headache

# Phenomena in Lexical Semantics

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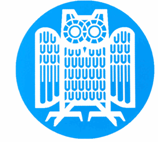
## Synonymy

*Twenty-eight states had reductions in the number of automobile accidents.*

*Twenty-eight states had reductions in the number of car accidents.*

# Phenomena in Lexical Semantics

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## Hyponymy

*A car accident happened yesterday on the Stadtautobahn.*

*A motor-vehicle accident happened yesterday on the Stadtautobahn.*

*No car accident happened yesterday on the Stadtautobahn.*

*No motor-vehicle accident happened yesterday on the Stadtautobahn.*

*Twenty-eight states had reductions in the number of motor-vehicle accidents.*

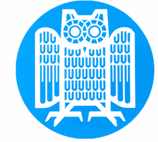
*Twenty-eight states had reductions in the number of car accidents.*

Meronymy, Antonymy, ...



# Phenomena in Lexical Semantics

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Verb Alternation/ thematic roles

*John sold the book for 19.95€.*

*The book sells for 19.95€.*

*Bees are swarming in the garden.*

*The garden is swarming with bees.*

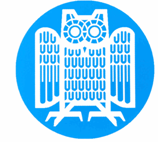
*The window broke*

*A rock broke the window*

*John broke the window with a rock*

# Phenomena in Lexical Semantics

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Inverse predicates/ thematic roles

*John is taller than Bill*

*Bill is shorter than John*

*Mary likes John*

*John pleases Mary*

*Mary gave Peter the book*

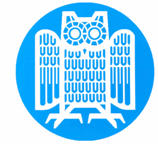
*Peter received the book from Mary*

*John sold the car to Bill for 3,000€*

*Bill bought the car from John for 3,000€*

# Phenomena in Lexical Semantics

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## Polysemy

*fast car / fast road / fast driver*

*feed rabbit / eat rabbit / wear rabbit*

*Bill read every book in the library.*

*Bill labeled every book in the library.*

## Non-literal interpretation: metonymy

*The ham sandwich wants to pay.*

*I am parked out back and have a flat tire.*

## Non-literal interpretation: metaphor

# Phenomena in Sentence Semantics

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## Higher-order expressions

John is a married piano player

John is married

John is a poor piano player

John is poor

# Phenomena in Sentence Semantics

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## Quantifier scope

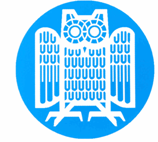
*Every student speaks two foreign languages.*

*Two foreign languages are spoken by every student.*

*A representative of every company saw most samples.*

# Phenomena in Sentence Semantics

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## Polarity and Monotonicity

*Bill got a degree in LST.*

*Bill got a degree.*

*Bill got a degree.*

*Bill got a degree in LST.*

*Bill didn't get a degree in LST.*

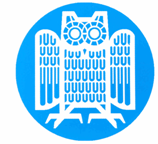
*Bill didn't get a degree.*

*Bill didn't get a degree.*

*Bill didn't get a degree in LST.*

# Phenomena in Sentence Semantics

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## Polarity and monotonicity

*A master student got a degree in LST.*

*A master student got a degree.*

*A student got a degree in LST.*

*Every master student got a degree in LST*

*Every master student got a degree.*

*Every student got a degree in LST.*

*Most master students got a degree in LST.*

*Exactly three master students got a degree in LST.*

# Phenomena in Sentence Semantics

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Plurals, cardinalities, distributive and collective interpretation

*The students worked.*

*All students worked.*

*Every student worked.*

*The students met.*

*All students met.*

*Every student met.*

*Two students presented a paper*

*Five students carried three pianos upstairs.*

*500,000 visitors ordered 1,200,000 cups of coffee.*

# Phenomena in Sentence Semantics

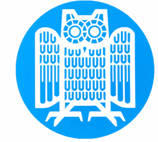
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*Many computational linguists in three Saarbruecken institutes work on a variety of interesting problems in language technology.*

# Phenomena in Discourse Semantics

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## Anaphora

*Bill likes his dog. He pampers him.*

*Bill likes his dog, although he sometimes bites him.*

*Bill likes his dog, although she sometimes bites him.*

## Ellipsis

*John loves Mary, and so does Bill.*

*John loves his wife, and so does Bill.*

# Phenomena in Discourse Semantics

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## Presupposition

*Bill regrets that his cat has died.*

*Bill doesn't regret that his cat has died.*

*Bill's cat has died.*

*Bill's cat hasn't died.*

*Bill owns a cat.*

*Bill doesn't own a cat.*

# Phenomena in Discourse Semantics

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## Information structure

*Who ate the cake? Bill ate the cake.*

*What did Bill eat? Bill ate the cake.*

*Only the CEOs of the startup companies were invited to the meeting.*