Semantics

These slides were produced by Hadas Kotek.

http://web.mit.edu/hkotek/www/

Sentence types

What is the meaning of a sentence?

The lion devoured the pizza.

Statement

Sentence types

What is the meaning of a sentence?

Who devoured the pizza?

Did the lion devour the pizza?

Question

Sentence types

What is the meaning of a sentence?

Do your homework!

Command

Sentence types

What is the meaning of a sentence?

It's cold here ….

Do you know what time it is?

Sentences might convey additional non-literal meaning

What do sentences mean?

(1) **The capital of Canada is Ottawa**

(2) **The capital of Canada is Montreal**

What do sentences mean?

(1) **The capital of Canada is Ottawa**

(2) **The capital of Canada is Montreal**

→The meaning of a sentence is related to whether it is true or false (its ***truth value***).

In the actual world:

– (1) is True

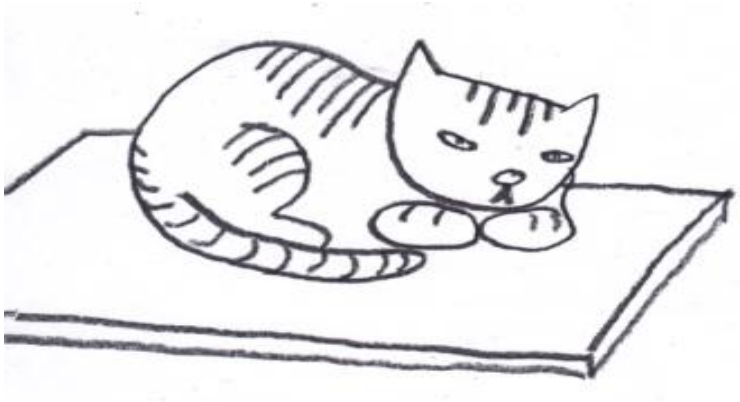
– (2) is False

What do sentences mean?

BUT: This can't be all, since the truth-values of sentences can change over time or situations

Reese is in room 20

The cat is on the mat



What do sentences mean?

We can grasp the meaning of a sentence without knowing whether it's true or false.

The name of the person sitting closest to the door starts with a "D."

What do sentences mean?

We can grasp the meaning of sentences we've never heard before.

The furry cat ate the red jellybean

Definition: Semantics and meaning

The ***semantic competence*** of a speaker:

The ability, when presented with a sentence and a situation, to tell whether the sentence is true or false in the situation.

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The ***semantic competence*** of a speaker:

The ability, when presented with a sentence and a situation, to tell whether the sentence is true or false in the situation.

To know the *meaning* of a sentence is to know its *truth conditions*.

– That is, we know what the world would have to look like in order for the sentence to be true.

Building a semantic system

How can we specify the meanings of infinitely many sentences in natural language?

The scary lion devoured the mushroom pizza that I ordered last night

Building a semantic system

Observation: The interpretation of a sentence depends on its syntactic structure. Different phrases make predictable contributions to the meaning of a sentence.

The cat chased the rat

Building a semantic system

Observation: The interpretation of a sentence depends on its syntactic structure. Different phrases make predictable contributions to the meaning of a sentence.

The cat chased the rat

The rat chased the cat

Building a semantic system

Observation: The interpretation of a sentence depends on its syntactic structure. Different phrases make predictable contributions to the meaning of a sentence.

The cat chased the rat

The grey cat chased the rat

The grey cat with the hat chased the rat

Building a semantic system

Observation: The interpretation of a sentence depends on its syntactic structure. Different phrases make predictable contributions to the meaning of a sentence.

The cat chased the rat

The cat chased the dog

Building a semantic system

Observation: The interpretation of a sentence depends on its syntactic structure. Different phrases make predictable contributions to the meaning of a sentence.

The cat chased the rat

The cat licked the rat

Building a semantic system

Observation: The interpretation of a sentence depends on its syntactic structure. Different phrases make predictable contributions to the meaning of a sentence.

The cat chased the rat

A cat chased the rat

Definition: Compositional semantics

The principle of compositionality:

The meaning of a sentence depends only on the meanings of its parts and on the way that they are syntactically combined.

Gottlob Frege

Definition: Compositional semantics

The principle of compositionality:

The meaning of a sentence depends only on the meanings of its parts and on the way that they are syntactically combined.

This image is in the public domain.
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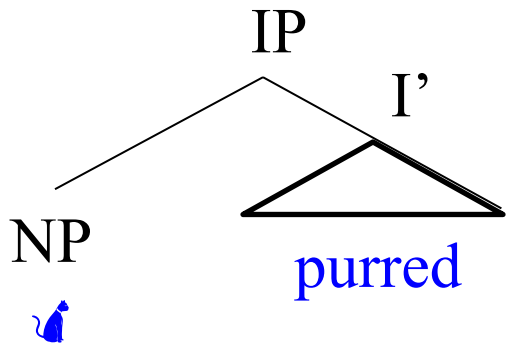
The task of the semantics of a language is to provide the truth-conditions of all the well-formed sentences in that language, and to do so in a compositional way

Basic modeling

Mitzi is gray

Mitzi is a cat

Mitzi purred



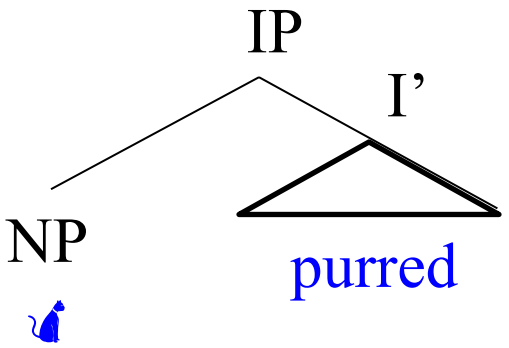
We can define *adjectives*, *nouns* and *intransitive verbs* as mathematical **sets** of individuals.

Basic modeling

Mitzi is gray

Mitzi is a cat

Mitzi purred



A **set** is a collection of objects.

Gray is the collection of all gray individuals.

Cat is the collection of all individuals who are cats.

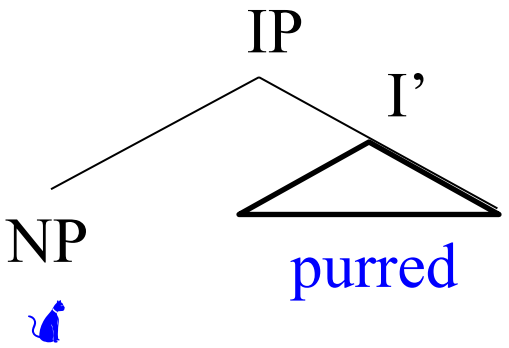
Purred is the collection of all individuals who purred.

Basic modeling

Mitzi is gray

Mitzi is a cat

Mitzi purred



Mitzi is a **member** of the
set of individuals that are gray.

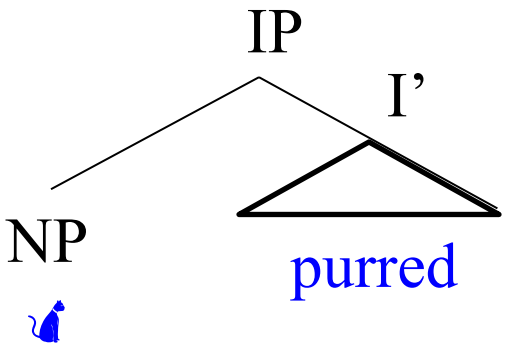
Mitzi $\in$ *Gray*

Basic modeling

Mitzi is gray

Mitzi is a cat

Mitzi purred



Mitzi is a **member** of the
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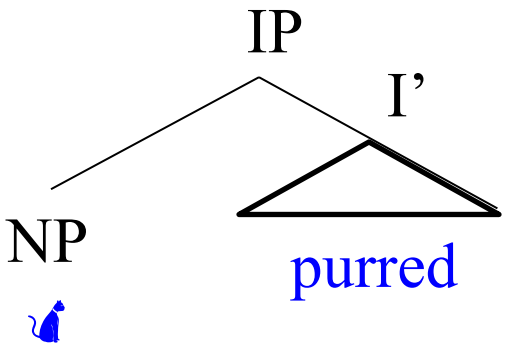


Mitzi is a **member** of the
set of individuals that purred.

Mitzi $\in$ *Purred*

Modification

Mitzi [$_{I}$, is a gray cat]

Mitzi is a member of the set of individuals who are gray AND a member of the set of individuals who are cats.

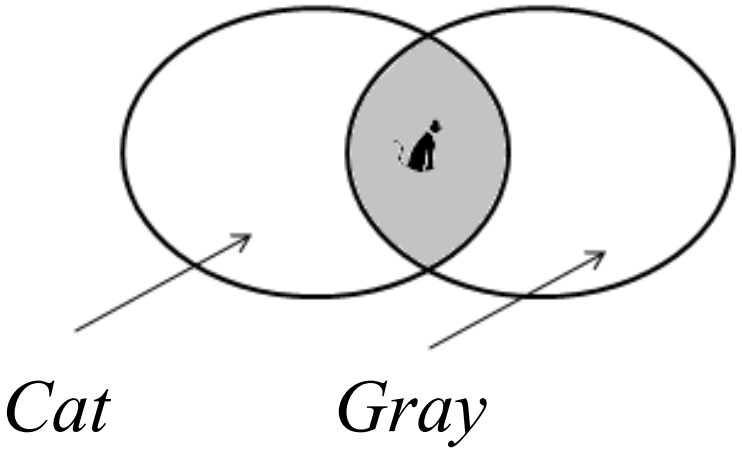
Mitzi $\in$ *Gray* AND Mitzi $\in$ *Cat*

Modification

Mitzi [$_I$, is a gray cat]

Set intersection: The set that results from combining two other sets

Mitzi $\in$ *Gray* $\cap$ *Cat*



Modification

Set intersection can describe other adjectives too:

Mitzi is a *gray* cat

Gianni is an *Italian* waiter

T-Rex is a *carnivorous* dinosaur

This is a *round* ball

These are called **intersective adjectives**.

Modification

Intersective adjectives conform to an **entailment** pattern.

Mitzi is a *gray* cat

$\Rightarrow$ Mitzi is a cat

$\Rightarrow$ Mitzi is gray

Modification

Intersective adjectives conform to an **entailment** pattern.

Mitzi is a *gray* cat

$\Rightarrow$ Mitzi is a cat

$\Rightarrow$ Mitzi is gray

A entails B iff whenever A is true, B is true.

Modification

There are also **non-intersective** adjectives**:**

George is a *former* president

This is a *fake* diamond

Modification

There are also **non-intersective** adjectives**:**

George is a *former* president

This is a *fake* diamond

The entailment pattern doesn't hold:

George is a former president

⇒ George is a president [not valid]

⇒ ??George is former [not valid]

Modification

There are also **non-intersective** adjectives**:**

George is a *former* president

This is a *fake* diamond

In fact:

George is a former president

$\Rightarrow$ George is not a president

$\Rightarrow$ George was a president in the past

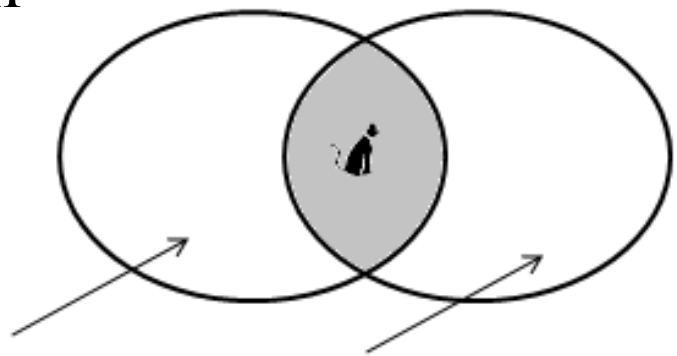
Connectives

Mitzi [$_I$, is gray and furry]

Connectives can be described in set terms.

AND denotes set intersection

Gray ∩ *Furry*



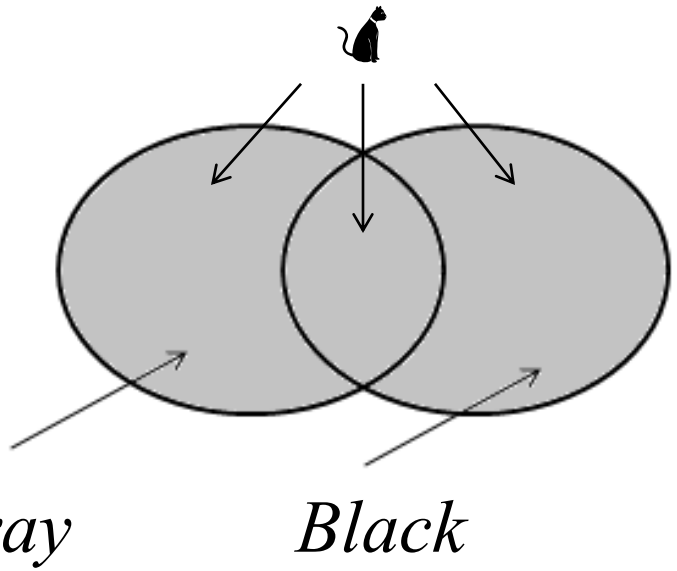
Connectives

Mitzi [$_I$, is gray or black]

Connectives can be described in set terms.

OR denotes set **union**

Gray $\cup$ *Black*



Interim summary

Nouns, *intransitive verbs*, and *adjectives* can be described using *set intersection*.

$$\textbf{Mitzi} \left\{ \begin{array}{l} \textbf{is a cat} \\ \textbf{is gray} \\ \textbf{purred} \end{array} \right. = \text{🐈} \in \left\{ \begin{array}{l} \mathit{Cat} \\ \mathit{Gray} \\ \mathit{Purred} \end{array} \right.$$

Interim summary

AND can also be described using *set intersection*.

Mitzi is gray AND furry =  $\in$ $Gray \cap Furry$

OR can also be described using *set union*.

Mitzi is gray OR black =  $\in$ $Gray \cup Black$

More modeling

Proper names pick out individuals in the world.

John danced

More modeling

Proper names pick out individuals in the world.

John danced

What does *some boy* refer to?

Some boy danced

More modeling

Proper names pick out individuals in the world.

John danced

What does *some boy* refer to?

Some boy danced

What about *no boy*?

No boy danced

Determiners

English has several additional determiners:

***Some* boy danced**

***No* boy danced**

***Three* boys danced**

***More than half* of the boys danced**

***Every* boy danced**

Determiners

How do we model determiners?

***Some* boy danced**

***No* boy danced**

***Three* boys danced**

***More than half* of the boys danced**

***Every* boy danced**

Determiners

How do we model determiners?

***Some* boy danced**

***No* boy danced**

***Three* boys danced**

***More than half* of the boys danced**

***Every* boy danced**

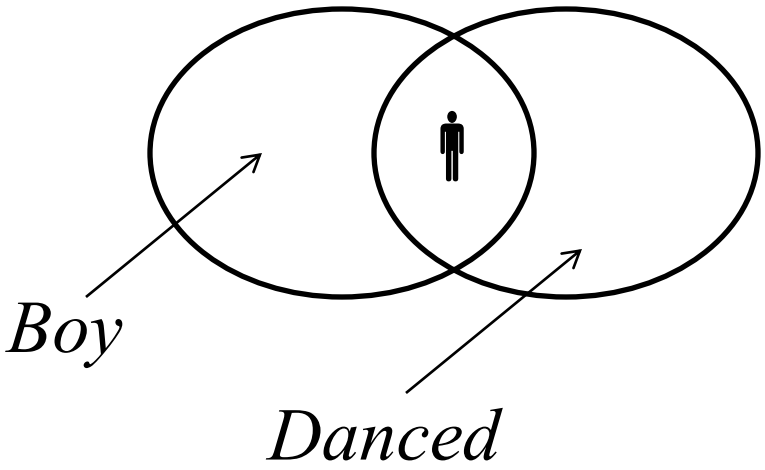
NPs with determiners don't refer to individuals.
Rather, determiners denote **set relations**.

Determiners

***Some* boy danced**

The **intersection** of the set of boys and the set of dancers is not empty

$Boy \cap Danced \neq \emptyset$

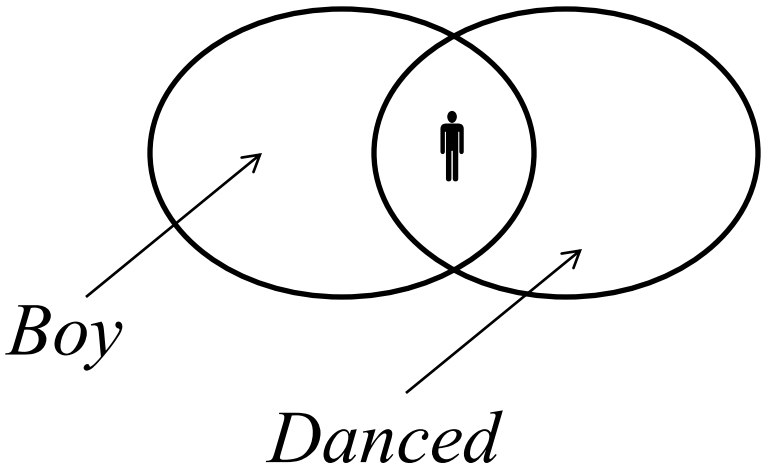


Determiners

***Some* boy danced**

Can there be boys who are not dancers?

Can there be dancers who are not boys?

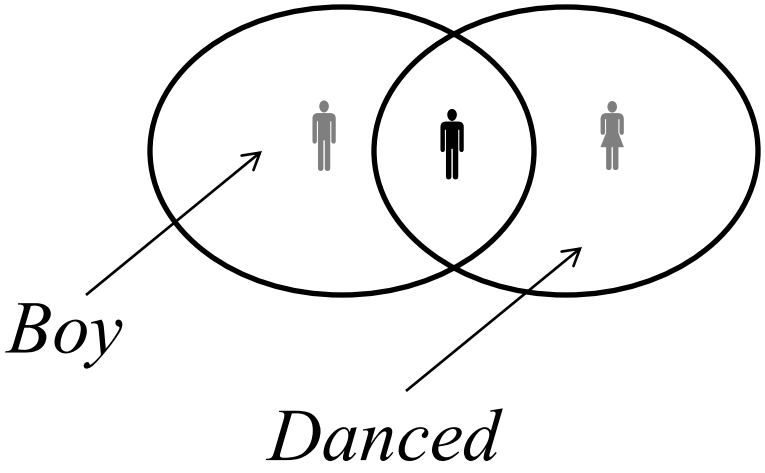


Determiners

***Some* boy danced**

Can there be boys who are not dancers? **Yes.**

Can there be dancers who are not boys? **Yes.**

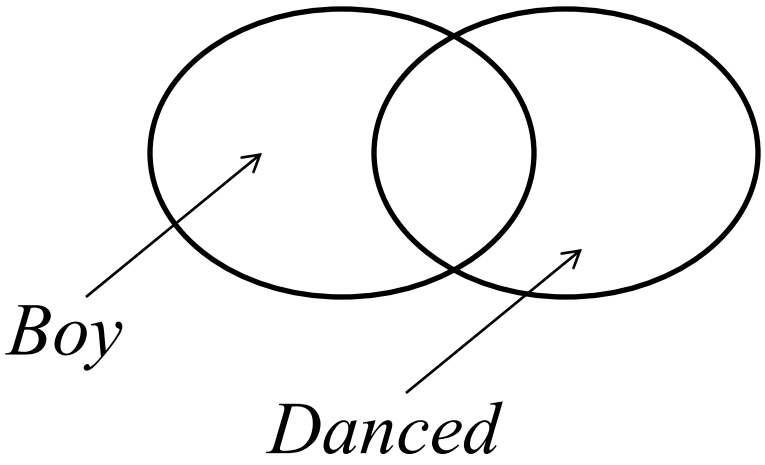


Determiners

***No* boy danced**

The **intersection** of the set of boys and the set of dancers is empty

$$Boy \cap Danced = \varnothing$$

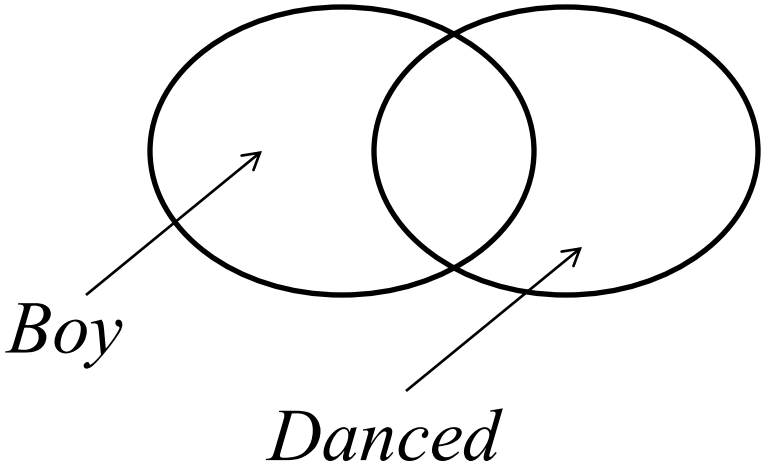


Determiners

***No* boy danced**

Can there be boys who are not dancers?

Can there be dancers who are not boys?

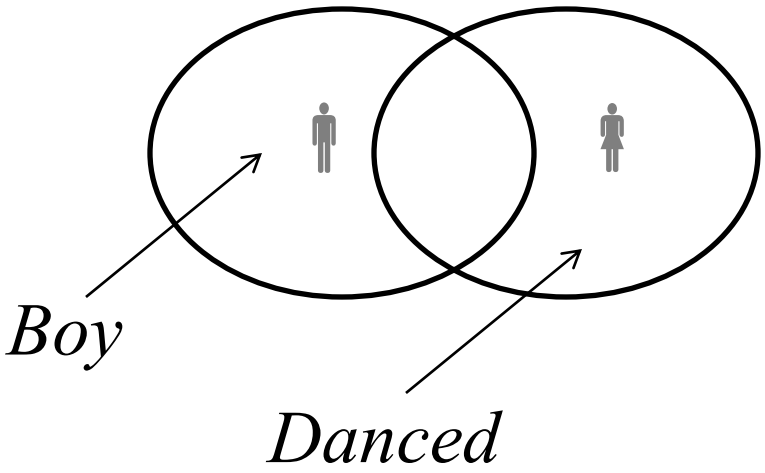


Determiners

***No* boy danced**

Can there be boys who are not dancers? **Yes.**

Can there be dancers who are not boys? **Yes.**

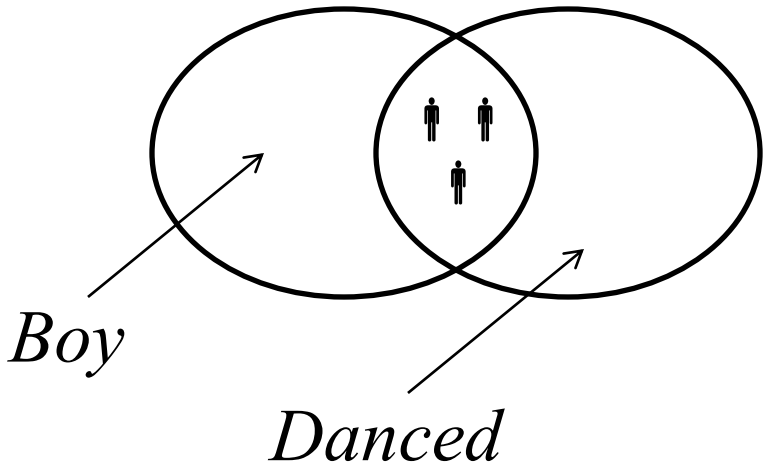


Determiners

***Three* boys danced**

The **intersection** of the set of boys and the set of dancers contains three elements.

$| Boy \cap Danced | = 3$

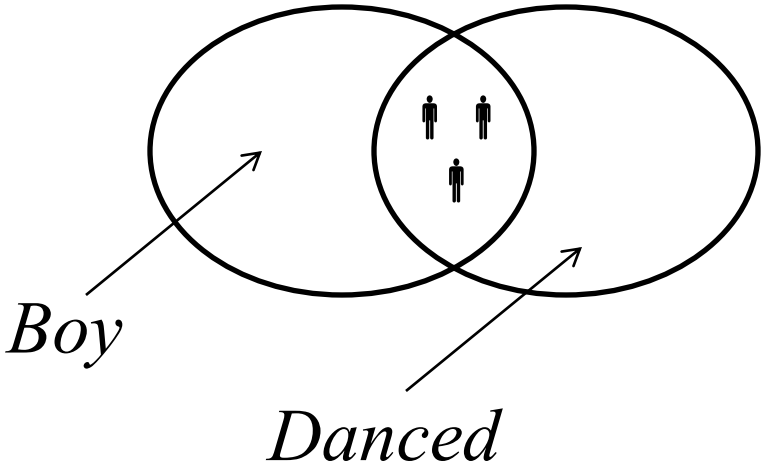


Determiners

***Three* boys danced**

Can there be boys who are not dancers?

Can there be dancers who are not boys?

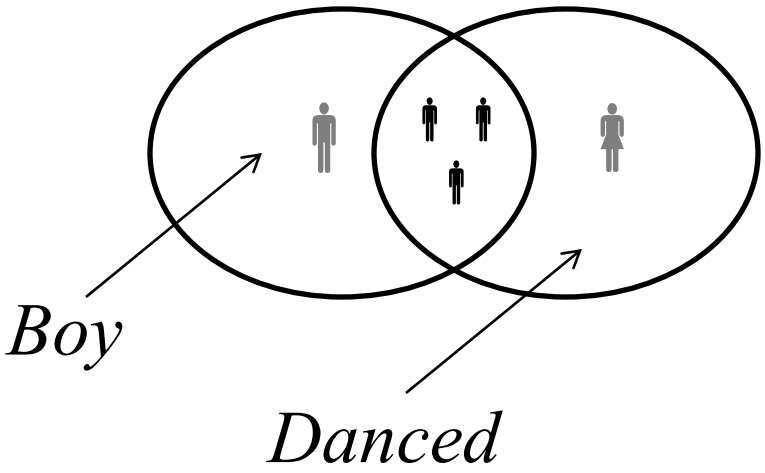


Determiners

***Three* boys danced**

Can there be boys who are not dancers? **Yes.**

Can there be dancers who are not boys? **Yes.**

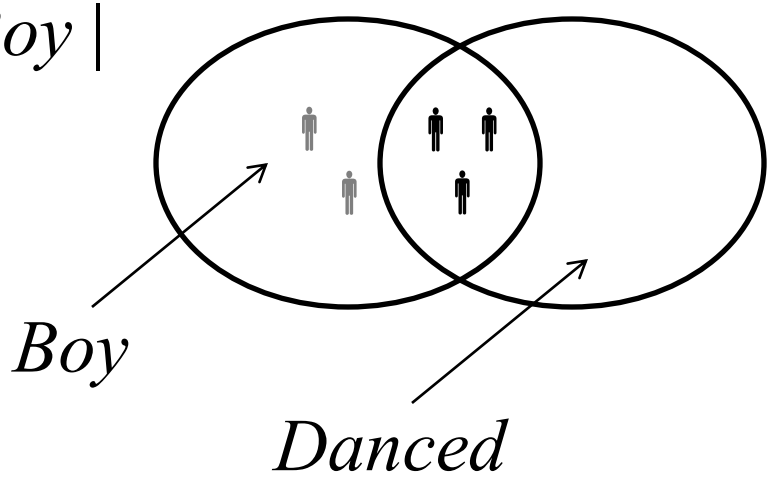


Determiners

***More than half* of the boys danced**

The **intersection** of the set of boys and the set of dancers contains more than half of all the boys.

$| Boy \cap Danced | > \frac{1}{2} | Boy |$

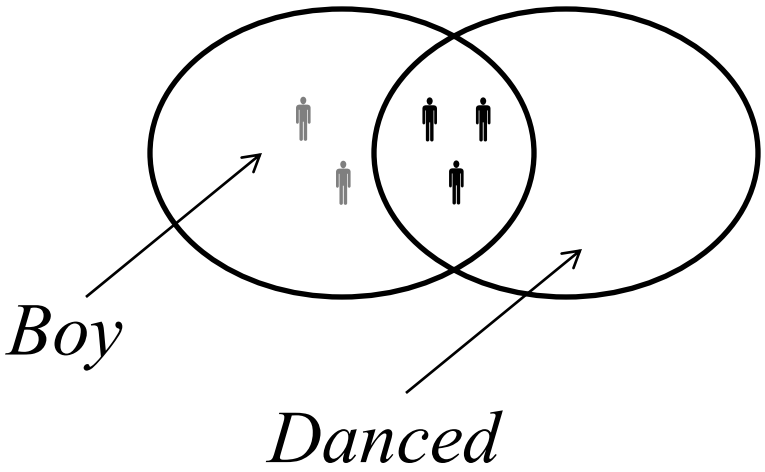


Determiners

***More than half* of the boys danced**

Can there be boys who are not dancers?

Can there be dancers who are not boys?

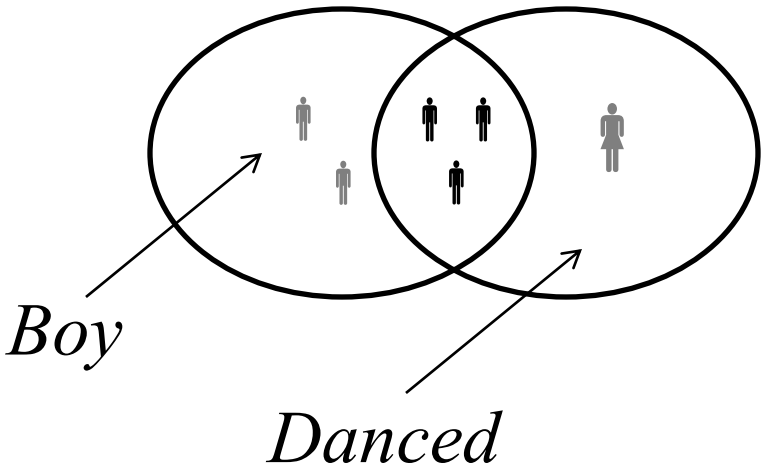


Determiners

***More than half* of the boys danced**

Can there be boys who are not dancers? **Yes (but...)**

Can there be dancers who are not boys? **Yes.**

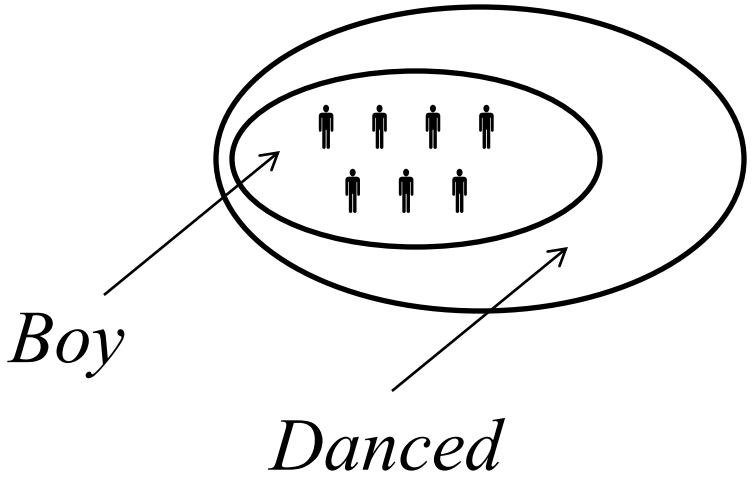


Determiners

***Every* boy danced**

The set of boys is a **subset** of the set of dancers.

$Boy \subseteq Danced$

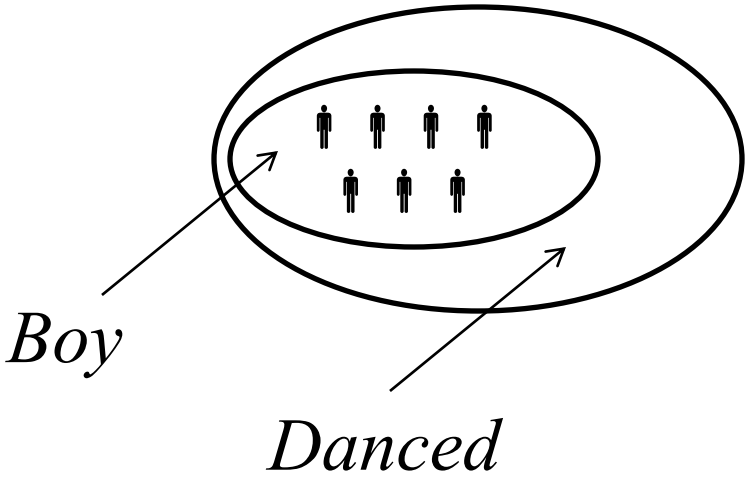


Determiners

***Every* boy danced**

Can there be boys who are not dancers?

Can there be dancers who are not boys?

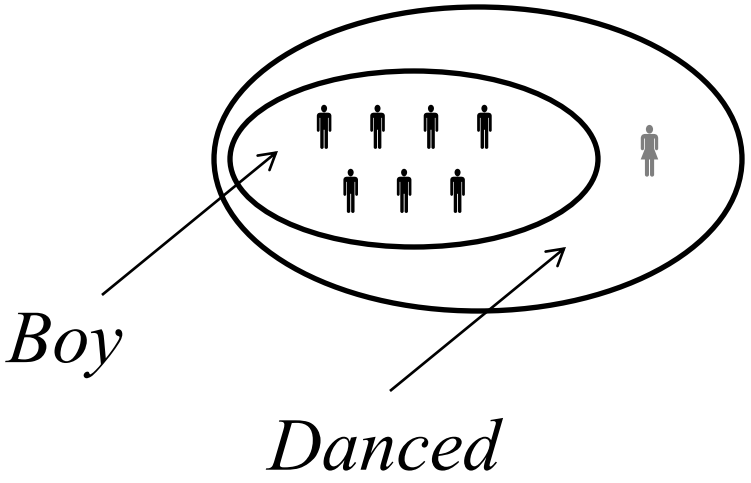


Determiners

***Every* boy danced**

Can there be boys who are not dancers? **No.**

Can there be dancers who are not boys? **Yes.**



Determiners summary

All the sentences we have seen have the structure:

***Det*(A)(B)**

Some(*Boy*)(*Danced*)

Three(*Boy*)(*Danced*)

More than half(*Boy*)(*Danced*)

No(*Boy*)(*Danced*)

Every(*Boy*)(*Danced*)

Determiners summary

All the sentences we have seen have the structure:

***Det*(A)(B)**

Some$(Boy)(Danced)$ $\Leftrightarrow$ $Boy \cap Danced \neq \emptyset$

Three$(Boy)(Danced)$

More than half$(Boy)(Danced)$

No$(Boy)(Danced)$

Every$(Boy)(Danced)$

Determiners summary

All the sentences we have seen have the structure:

***Det*(A)(B)**

$\textbf{\textit{Some}}(Boy)(Danced) \quad \Leftrightarrow \quad Boy \cap Danced \neq \varnothing$

$\textbf{\textit{Three}}(Boy)(Danced) \quad \Leftrightarrow \quad |\, Boy \cap Danced \,| = 3$

***More than half*(*Boy*)(*Danced*)**

***No*(*Boy*)(*Danced*)**

***Every*(*Boy*)(*Danced*)**

Determiners summary

All the sentences we have seen have the structure:

***Det*(A)(B)**

$\textbf{\textit{Some}}(Boy)(Danced) \quad \Leftrightarrow \quad Boy \cap Danced \neq \varnothing$

$\textbf{\textit{Three}}(Boy)(Danced) \quad \Leftrightarrow |\, Boy \cap Danced \,| = 3$

$\textbf{\textit{More than half}}(Boy)(Danced) \quad \Leftrightarrow |\, Boy \cap Danced \,| > \tfrac{1}{2} |\, Boy \,|$

$\textbf{\textit{No}}(Boy)(Danced)$

$\textbf{\textit{Every}}(Boy)(Danced)$

Determiners summary

All the sentences we have seen have the structure:

***Det*(A)(B)**

$$\textbf{\textit{Some}}(Boy)(Danced) \quad \Leftrightarrow \quad Boy \cap Danced \neq \varnothing$$

$$\textbf{\textit{Three}}(Boy)(Danced) \quad \Leftrightarrow \quad |\, Boy \cap Danced \,| = 3$$

$$\textbf{\textit{More than half}}(Boy)(Danced) \quad \Leftrightarrow \quad |\, Boy \cap Danced \,| > \tfrac{1}{2} |\, Boy \,|$$

$$\textbf{\textit{No}}(Boy)(Danced) \quad \Leftrightarrow \quad Boy \cap Danced = \varnothing$$

$$\textbf{\textit{Every}}(Boy)(Danced)$$

Determiners summary

All the sentences we have seen have the structure:

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$$\textbf{\textit{Some}}(Boy)(Danced) \quad \Leftrightarrow \quad Boy \cap Danced \neq \varnothing$$

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$$\textbf{\textit{More than half}}(Boy)(Danced) \quad \Leftrightarrow \quad |\, Boy \cap Danced \,| > \tfrac{1}{2} |\, Boy \,|$$

$$\textbf{\textit{No}}(Boy)(Danced) \quad \Leftrightarrow \quad Boy \cap Danced = \varnothing$$

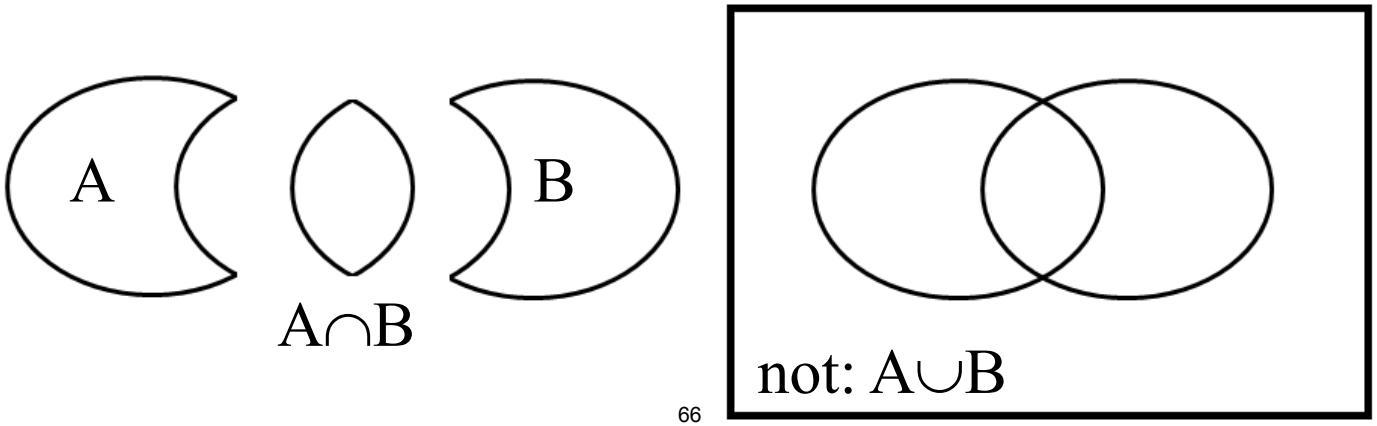
$$\textbf{\textit{Every}}(Boy)(Danced) \quad \Leftrightarrow \quad Boy \subseteq Danced$$

Properties of determiners

All the sentences we have seen have the structure:

***Det*(A)(B)**

All the determiners we have seen so far put restrictions on members of set A, but not on members of set B.

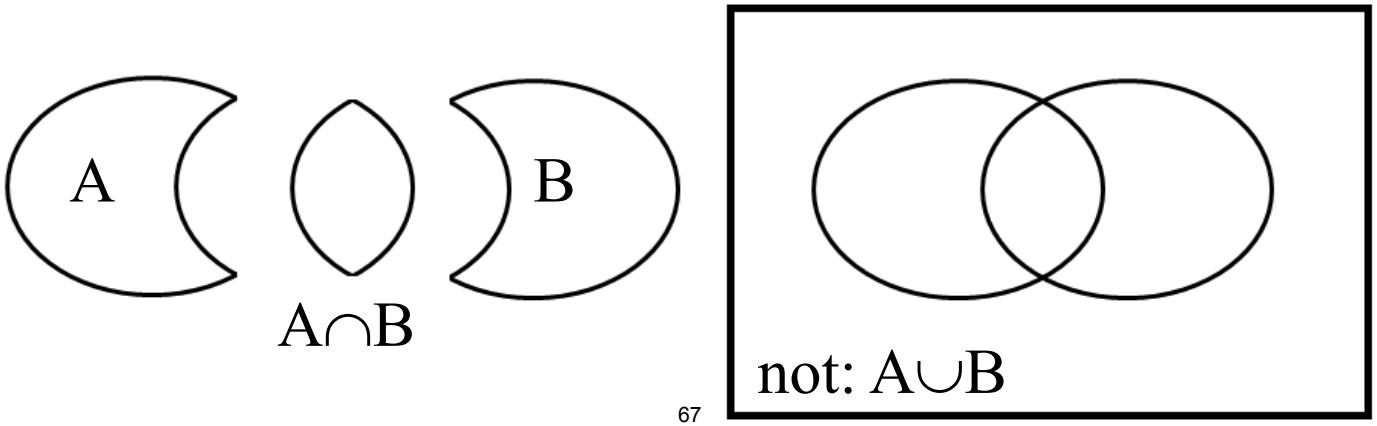


Properties of determiners

All the sentences we have seen have the structure:

***Det*(A)(B)**

Are there determiners that put restrictions on set B?



Properties of determiners

All the sentences we have seen have the structure:

***Det*(A)(B)**

For example, *every-non*(A)(B)

***blarg* boy danced**
= every non-boy danced

That is: $A^{-} \subseteq B$

Properties of determiners

All the sentences we have seen have the structure:

***Det*(A)(B)**

For example, Reverse-*mth*(A)(B)

***blick* boys danced**

= more than half of the dancers are boys

That is: $|A \cap B| > \frac{1}{2}|B|$

Conservativity

Natural language determiners only "care" about elements that satisfy their first argument.

Det is **conservative** if *Det*(A)(B) ⇔ *Det*(A)(A∩B):

***every*(boy)(danced)** conservative

= every boy danced

= every boy is a boy that danced

***every-non*(boy)(danced)** non-conservative

= every non-boy danced

≠ every non-boy is a boy that danced [*]

Conservativity

Natural language determiners only "care" about elements that satisfy their first argument.

Det is **conservative** if *Det*(A)(B) ⇔ *Det*(A)(A∩B):

***more than half*(boy)(danced)** conservative

= more than half of the boys danced

= more than half of the boys are boys who danced

***Reverse-mth*(boy)(danced)** non-conservative

= more than half of the dancers are boys

≠ more than half of the boys who danced are boys [*]

Conservativity

Universal: All natural language determiners are conservative.

Therefore: no language has a simple determiner that means *every-non* or Reverse-*mth*

blarg **boys danced** Does not exit!

= every non-boy danced

blick **boys danced** Does not exit!

= more than half of the dancers are boys

An application: Explaining entailment patterns

John sings and John dances

$\Rightarrow$ John sings and dances

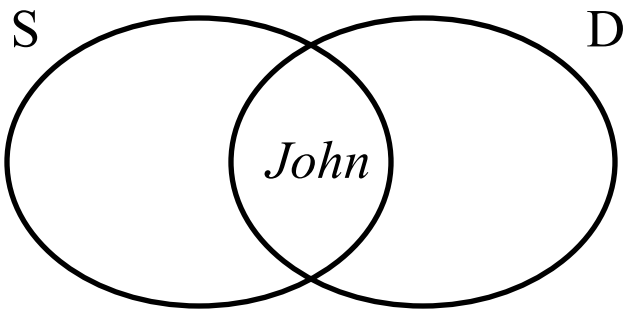
Some boy sings and some boy dances

$\not\Rightarrow$ Some boy sings and dances

An application: Explaining entailment patterns

John sings and John dances

⇒ John sings and dances



An application: Explaining entailment patterns

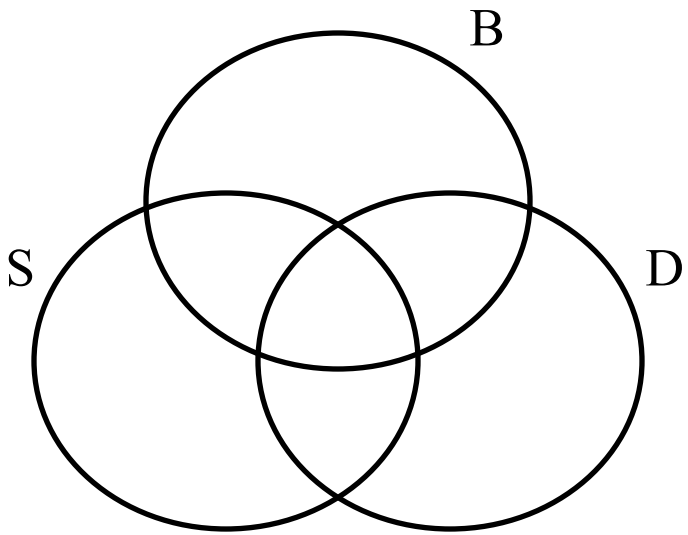
Some boy sings and some boy dances

$\not\Rightarrow$ Some boy sings and dances

An application: Explaining entailment patterns

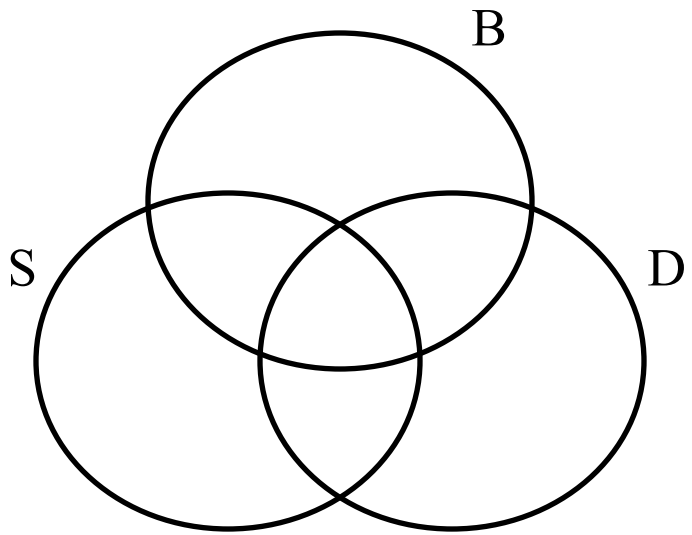
Some boy sings and some boy dances

$\not\Rightarrow$ Some boy sings and dances



An application: Explaining entailment patterns

Some boy sings and some boy dances



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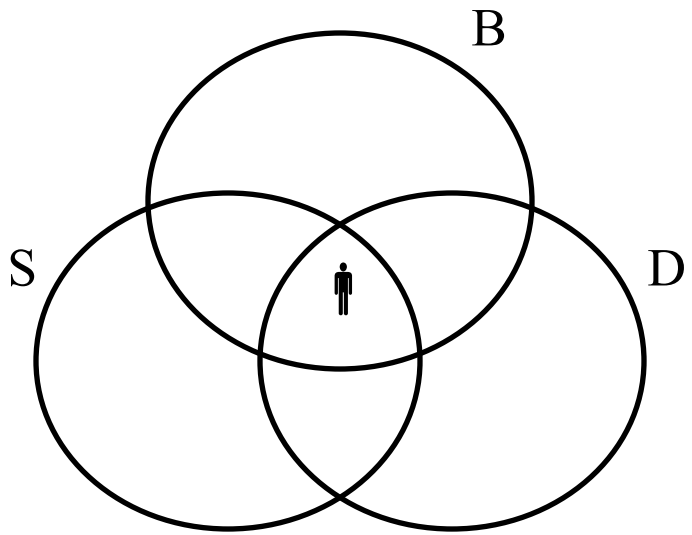

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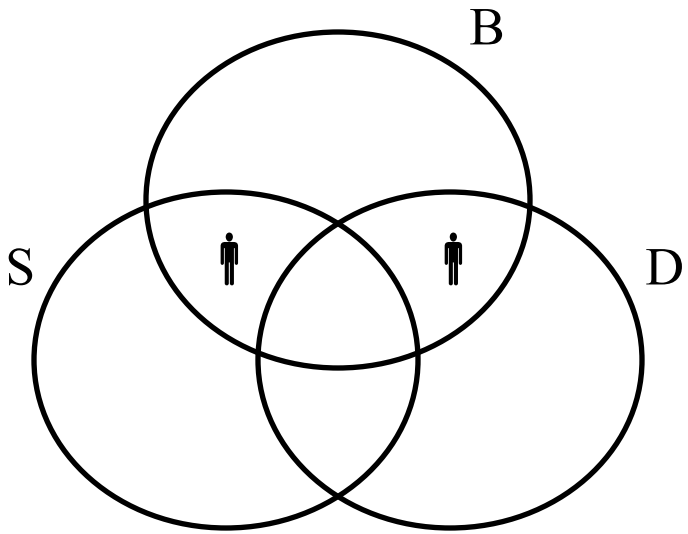

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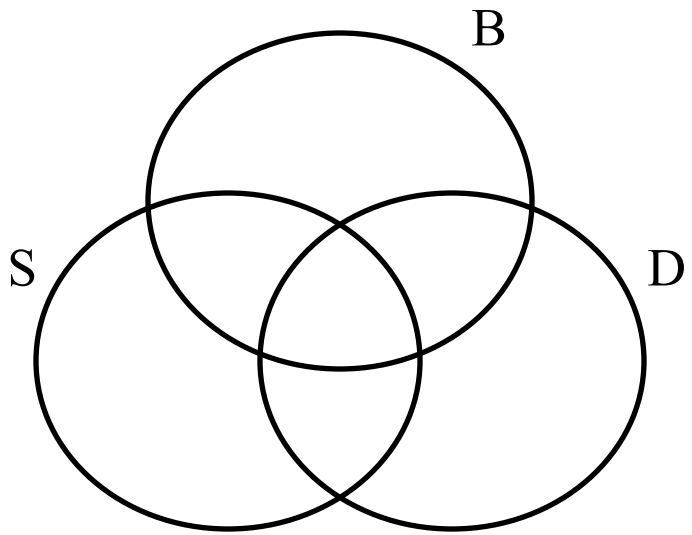

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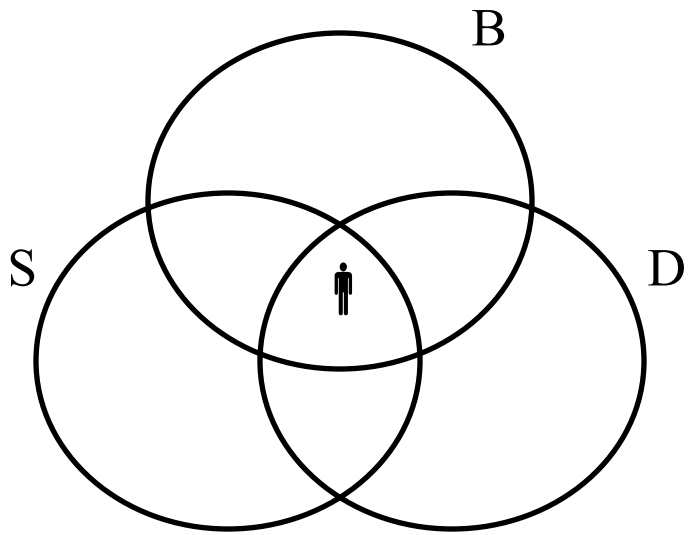

An application: Explaining entailment patterns

Some boy sings and some boy dances

$\not\Rightarrow$ Some boy sings and dances

A entails B iff whenever A is true, B is true.

We can find a situation where A is true but B is false.

Hence, A does not entail B

The definite article

What is the meaning of the definite article?

***Some* cat purred**

***Every* cat purred**

***The* cats purred**

The definite article

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***Some* cat purred**	$\Leftrightarrow$	$Cat \cap Purred = \varnothing$
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At first glance, *the* has a meaning similar to *every*

The definite article

We might define *the* as:

The cats purred $\Leftrightarrow$ $Cat \subseteq Purred$

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Does this work in this context?

The definite article

We might define *the* as:

The cats purred $\Leftrightarrow$ $Cat \subseteq Purred$

Does this work in this context?

Context: There are three cats.

Every cat purred

The cats purred

#The cat purred

The definite article

The cat purred

The expression *the cat* presupposes:

– Existence: there exists a cat

– Uniqueness: there is exactly one (relevant) cat

The definite article

The cat purred

The expression *the cat* presupposes:

- Existence: there exists a cat
- Uniqueness: there is exactly one (relevant) cat

When there is exactly one relevant individual in NP, *the* returns that individual.

the cat defined iff there is one $c \in Cat$. Returns c.

Presuppositions of *the*

The presuppositions of the definite often spring into existence, even if they weren't known beforehand.

I forgot to feed the cat this morning

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Presuppositions of *the*

The presuppositions of the definite often spring into existence, even if they weren't known beforehand.

I forgot to feed the cat this morning

You will **accommodate** the fact that I have a cat.

If no one objects to what I said, the assumption that I have a cat will be added to the **common ground** of our conversation.

Accommodation

How easy it is to accommodate depends on the plausibility of what I said.

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Context: We are at my house and you hear some scratching noises outside.

(1) **The cat is at the door.**

(2) **The giraffe is at the door.**

(3) **I keep a giraffe here. The giraffe is at the door.**

Accommodation

Normally, we assume that speakers intend to say things that are grammatical, relevant, and – often – true.

In the closet, you will find the blue coat

Accommodation

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In the closet, you will find the blue coat

Suppose that after I said this sentence, you open the closet and find only a black coat.

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In the closet, you will find the blue coat

Suppose that after I said this sentence, you open the closet and find only a black coat.

You may assume I just got the color confused.

Accommodation

Normally, we assume that speakers intend to say things that are grammatical, relevant, and – often – true.

In the closet, you will find the blue coat

Suppose that after I said this sentence, you open the closet and find only a black coat.

Or you might assume you got the color confused and it's really a dark blue coat.

Accommodation

We use a similar process to choose the meaning of ambiguous sentences.

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Successful lawyers and linguists are always rich

Accommodation

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a. [Successful lawyers] and linguists are always rich

b. Successful [lawyers and linguists] are always rich

Accommodation

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a. [Successful lawyers] and linguists are always rich

b. Successful [lawyers and linguists] are always rich

Since (a) is obviously false, you'll normally conclude that I meant (b).

Accommodation

We use this process to assign implicit parameters in a way that would make sentences true.

<u>Everybody in the room</u> is taller than me

Accommodation

We use this process to assign implicit parameters in a way that would make sentences true.

Everybody in the room is taller than me

Context: There are four people in the room; you, me, and two other people who I don't know.

a. You: **We are brothers.**

b. You: **We are four, so we can play bridge.**

Accommodation

Sometimes we can't accommodate a presupposition.

I forgot to feed the cat this morning!

I forgot to feed the giraffe this morning!

Accommodation

Sometimes we can't accommodate a presupposition.

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The TA is sitting in the front row

→ Uniqueness is violated!

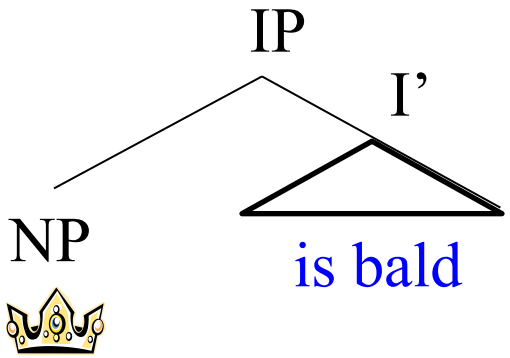
The king of France is bald

→ Existence is violated!

Conclusion

The king of France is bald

Modeling using sets: We defined *intransitive verbs*, *nouns* and *adjectives* as sets of individuals.



Conclusion

The king of France is bald

Modeling using sets: We defined connectives (*and*, *or*) and determiners (*some*, *every*, *no*, *three*, *more than half*) as relations between two sets.

Conclusion

Compositionality: We calculated the meaning of sentences from the meaning of their parts and the syntactic structure they were in.

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The meanings we calculated derived the **truth conditions** of the sentences.

When combined with a context, we yield a **truth value**

Conclusion

Finally, we discussed the definite article and its **presuppositions**.

The king of France is bald

→ Existence

→ Uniqueness

24.900 Introduction to Linguistics
Fall 2012