

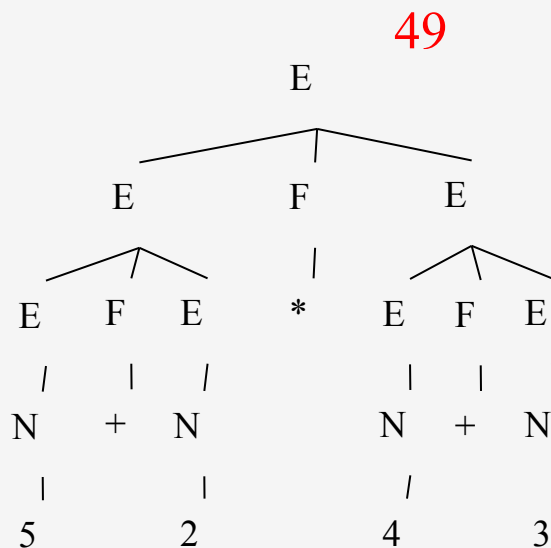
**NLP**

# Introduction to NLP

*Semantics*

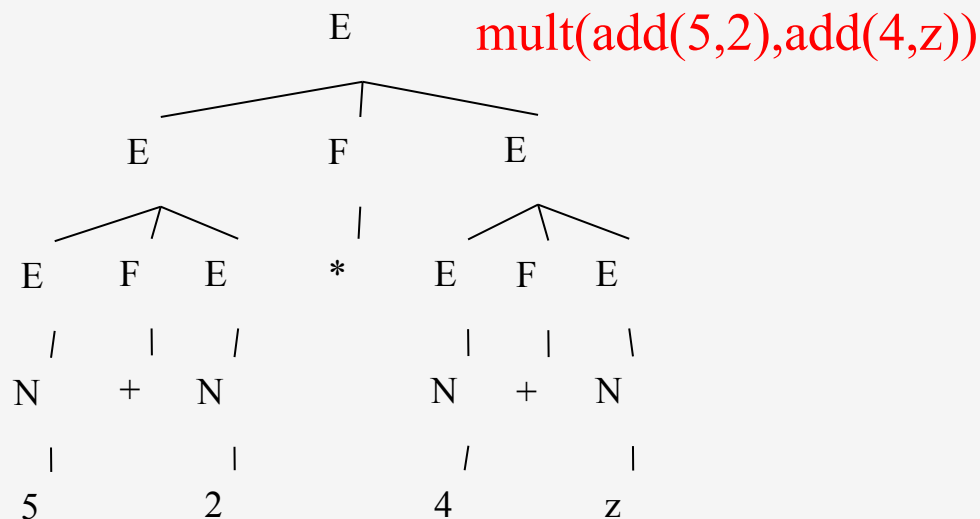
# Semantics

- What is the meaning of:  $(5+2)*(4+3)$ ?
- Parse tree



# Semantics

- What if we had  $(5+2)*(4+z)$ ?



# What About (English) Sentences?

- Every human is mortal.
- ??

# Representing Meaning

- Capturing the meaning of linguistic utterances using formal notation
- Linguistic meaning
  - “It is 8 pm”
- Pragmatic meaning
  - “It is time to leave”
- Semantic analysis:
  - Assign each word a meaning
  - Combine the meanings of words into sentences
- *I bought a book:*
  - $\exists x,y. \text{Buying}(x) \wedge \text{Buyer}(\text{speaker},x) \wedge \text{BoughtItem}(y,x) \wedge \text{Book}(y)$   
*Buying (Buyer=speaker, BoughtItem=book)*

# Entailment and Presupposition

- Entailment
  - One fact follows from another
  - “All cats have whiskers” and “Martin is a cat” entail the statement “Martin has whiskers”
  - “Martin has whiskers and a tail” entails “Martin has whiskers”
- Presupposition
  - “The Queen of Utopia is dead” presupposes that Utopia has a queen

# Entailment and Presupposition

- NACLO problem from 2010
- Author: Aleka Blackwell
- <http://www.nacloweb.org/resources/problems/2010/M.pdf>
- <http://www.nacloweb.org/resources/problems/2010/MS.pdf>



Think about the meaning of the following sentence:

(1) The 2010 Winter Olympics were in Canada.

Assuming that we only know sentence 1 to be true, is sentence 2 necessarily true?

(2) The 2010 Winter Olympics were in Vancouver.

The answer is no. Assuming we only know sentence 1 to be true, the 2010 Winter Olympics could have taken place in any Canadian city, but not necessarily in Vancouver.

Now examine the relationship between sentences 3 and 4. Assuming sentence 3 is true, is sentence 4 now necessarily true?

(3) The 2010 Winter Olympics were in Vancouver.

(4) The 2010 Winter Olympics were in Canada.

Now the answer is yes. Since Vancouver is a Canadian city, any event which occurs in Vancouver necessarily occurs in Canada.

**The logical relationship which holds between sentences 3 and 4 is called an *entailment*.** In formal terms, sentence A entails sentence B if whenever A is true, B is necessarily true. The entailment relationship is typically represented graphically this way: A  $\models$  B.

Here are some more examples of the entailment relationship between sentences:

(5) Shaun White is a Winter Olympian  $\models$  Shaun White is an Olympian

(6) Shaun White is an Olympian  $\models$  Shaun White is an athlete

(7) Shaun White won a gold medal  $\models$  Someone won a gold medal

Notice that the entailment relationship must hold in the specified direction but will not necessarily hold in both directions. So, sentence 3 entails sentence 4 even though sentence 4 does not entail sentence 3.

# Entailment and Presupposition

Now examine the relationship between sentences 8 and 9.

(8) I did not see Shaun White win the gold medal in the 2010 Winter Olympics.

(9) Shaun White won the gold medal in the 2010 Winter Olympics.

**Sentences 8 and 9 illustrate a relationship called *presupposition*.** In this pair of sentences, the information presented in sentence 9 is what the speaker assumes (or presupposes) to be the case when uttering sentence 8. That is, to say “*I did not see Shaun White win the gold medal*” assumes the belief that Shaun White won a gold medal. In formal terms, sentence A presupposes sentence B if A not only implies B but also implies that the truth of B is somehow taken for granted. A presupposition of a sentence is thus part of the background against which its truth or falsity is judged. The presupposition relationship is typically represented graphically this way: A >> B

Here are some more examples of presuppositions (where the first sentence in each pair presupposes the second):

(10) I regret not seeing Shaun White's gold medal run >> Shaun White had a gold medal run

(11) Shaun White continues to rule the halfpipe >> Shaun White had been ruling the halfpipe

(12) Snowboarding is now an Olympic sport >> Snowboarding was once not an Olympic sport

# Entailment and Presupposition

For any given pair of sentences, the entailment and presupposition relationships may or may not hold, together or separately.

For each of the following possible combinations, your task is to provide one example of a pair of sentences with an explanation of your reasoning for proposing your pair of sentences as a valid and convincing example in each case.

- a. A pair of sentences in which sentence A **neither entails nor presupposes** sentence B.
- b. A pair of sentences in which sentence A **entails and presupposes** sentence B.
- c. A pair of sentences in which sentence A **presupposes but does not entail** sentence B.
- d. A pair of sentences in which sentence A **entails but does not presuppose** sentence B.

# Answers

For any given pair of sentences, the entailment and presupposition relationships may or may not hold, together or separately.

a. A pair of sentences in which sentence A **neither entails nor presupposes** sentence B.

A. Shaun White is a Winter Olympian.

B. The 2010 Winter Olympics were in Vancouver.

Explanation: Sentences A and B are unrelated.

Entailment: Given that sentence A is true, there is no way to know whether sentence B is true or false. If Shaun White is a Winter Olympian, the 2010 Winter Olympics may or may not have taken place in Vancouver. Thus, there is no entailment relationship between these two sentences.

Presupposition: When uttering sentence A, a speaker would not take sentence B for granted (or assume that sentence B is background information against which the truth or falsity of sentence A would be judged). A speaker would not utter "Shaun White is a Winter Olympian" and assume the belief/take for granted that the 2010 Winter Olympics were in Vancouver.

b. A pair of sentences in which sentence A **entails and presupposes** sentence B.

A. Shaun White continues to rule the halfpipe

B. Shaun White had been ruling the halfpipe.

Entailment: If sentence A is true, sentence B is necessarily true. The entailment relationship between these sentences relies on the meaning of the verb *continue* – to *continue to rule* the halfpipe, Shaun White had to be ruling the halfpipe already. Thus, sentence A entails sentence B.

Presupposition: When uttering sentence A, a speaker would take sentence B for granted (or assume that sentence B is background information against which the truth or falsity of sentence A would be judged). A speaker who utters "Shaun White continues to rule the halfpipe" assumes the belief/takes for granted that Shaun White had been ruling the halfpipe. Thus, sentence A presupposes sentence B.

# Entailment and Presupposition

- c. A pair of sentences in which sentence A **presupposes but does not entail** sentence B.
- A. I did not see Shaun White win the gold medal in the 2010 Winter Olympics.
  - B. Shaun White won the gold medal in the 2010 Winter Olympics.

Entailment: If sentence A is true, sentence B *may or may not* be true. The absence of an entailment relationship between these sentences relies on the words “did not see” – if it is true that I *did not see* Shaun White win the gold medal, then Shaun White may or may not have won the gold medal. Thus, sentence A does not entail sentence B.

Presupposition: When uttering sentence A, a speaker would take sentence B for granted (or assume that sentence B is background information against which the truth or falsity of sentence A would be judged). Specifically, a speaker who utters “I did not see Shaun White win the gold medal in the 2010 Winter Olympics” assumes the belief that Shaun White did actually win the gold medal in the 2010 Winter Olympics. Thus, sentence A presupposes sentence B.

# Entailment and Presupposition

- d. A pair of sentences in which sentence A **entails but does not presuppose** sentence B.
- A. Shaun White did not win the gold medal in the 2010 Winter Olympics.
  - B. Shaun White did not both win the gold medal in the 2010 Winter Olympics and injure his ankle.

Entailment: If Shaun White did not win the gold medal in the 2010 Winter Olympics, then he necessarily did not *both* win that gold medal *and* injure his ankle, since he definitely did not win the gold medal. If one fact is not the case (the fact presented in sentence A), then both facts cannot be the case, either (the fact presented in sentence A + the new fact added to it in sentence B). Thus if sentence A is true, sentence B is *necessarily* true. Thus, sentence A entails sentence B.

Presupposition: When uttering sentence A, a speaker would not take sentence B for granted (or assume that sentence B is a background against which the truth or falsity of sentence A would be judged). Specifically, by uttering “Shaun White did not win the gold medal in the 2010 Winter Olympics” a speaker could not assume the belief that Shaun White did not both win the gold and injure his ankle, or that Shaun White either won a gold medal or injured his ankle. Whether Shaun White injured his ankle would not be information taken for granted when uttering “Shaun White did not win the gold medal in the 2010 Winter Olympics.” Thus, sentence A does not presuppose sentence B.

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