# Meaning as Sense (Frege 1892)

The meaning of an expression is its **sense**, an abstract object that determines its reference.

Senses are functions that determine reference.

# Functions: a Reminder

- A function is an abstract (mathematical) object which, given an appropriate **input**, specifies a unique **output**.

  The square function ($f_{sq}$) outputs a unique number, given any number as input: $f_{sq}(2) = 4$, $f_{sq}(111) = 12,321$

  Two inputs could be mapped onto the same output: $f_{sq}(-2) = 4$, $f_{sq}(-111) = 12,321$

Some expressions, like proper names, have the same reference at any point in space-time.

Other expressions, in fact most expressions, have a reference that changes from one location to another.

**the president**, **republican**, **the World Series**, **admires**,...

The meaning (sense) of **the president** =

$$\begin{bmatrix} [\text{USA,1789}] & \rightarrow & \text{George Washington} \\ [\text{USA,1795}] & \rightarrow & \text{George Washington} \\ \dots & & \\ [\text{Uganda,1975}] & \rightarrow & \text{Idi Amin} \\ \dots & & \\ [\text{USA,1994}] & \rightarrow & \text{Bill Clinton} \\ \dots & & \\ [\text{USA,2011}] & \rightarrow & \text{Barack H. Obama} \\ [\text{France,2011}] & \rightarrow & \text{Nicolas Sarkozy} \\ \dots & & \end{bmatrix}$$

The meaning (sense) of the name **Barack Obama** =

$$\begin{bmatrix} [\text{USA,1789}] \rightarrow \text{Barack H. Obama} \\ [\text{USA,1795}] \rightarrow \text{Barack H. Obama} \\ \ldots \\ [\text{Uganda,1975}] \rightarrow \text{Barack H. Obama} \\ \ldots \\ [\text{USA,1994}] \rightarrow \text{Barack H. Obama} \\ \ldots \\ [\text{USA,2011}] \rightarrow \text{Barack H. Obama} \\ [\text{France,2011}] \rightarrow \text{Barack H. Obama} \\ \ldots \end{bmatrix}$$

# An Insight of Frege's

The meaning (**sense**) of a declarative clause is a proposition determined by the meanings of the parts and how they are put together.

The **reference** of a sentence is a truth value (**true** or **false**).

# A Typical Proposition

**The president is Texan**.

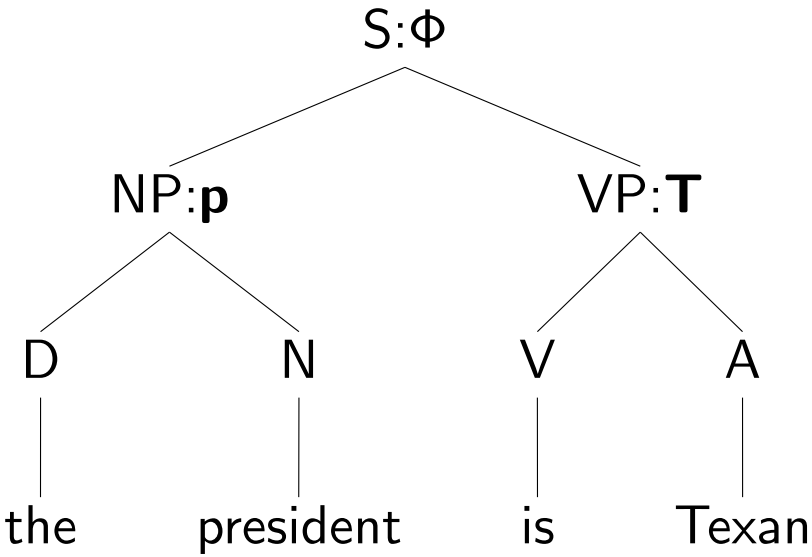
The proposition that, given any location in space-time, gives **true** just in case the unique individual who at that location holds the office of president is in the set of people who are from Texas.

The meaning (sense) of **The president is Texan** =

$$\begin{bmatrix} [\text{USA},1789] & \rightarrow & \text{false} \\ [\text{USA},1795] & \rightarrow & \text{false} \\ \ldots & & \\ [\text{Uganda},1975] & \rightarrow & \text{false} \\ \ldots & & \\ [\text{USA},2007] & \rightarrow & \text{true} \\ \ldots & & \\ [\text{USA},2011] & \rightarrow & \text{false} \\ [\text{France},2011] & \rightarrow & \text{false} \\ \ldots & & \end{bmatrix}$$

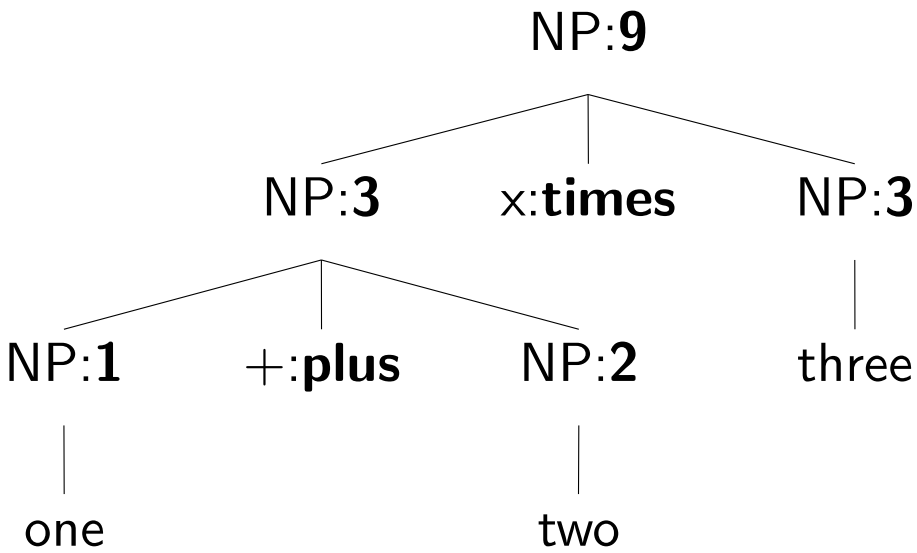
# Compositionality

First, pick a location **l** in space-time...

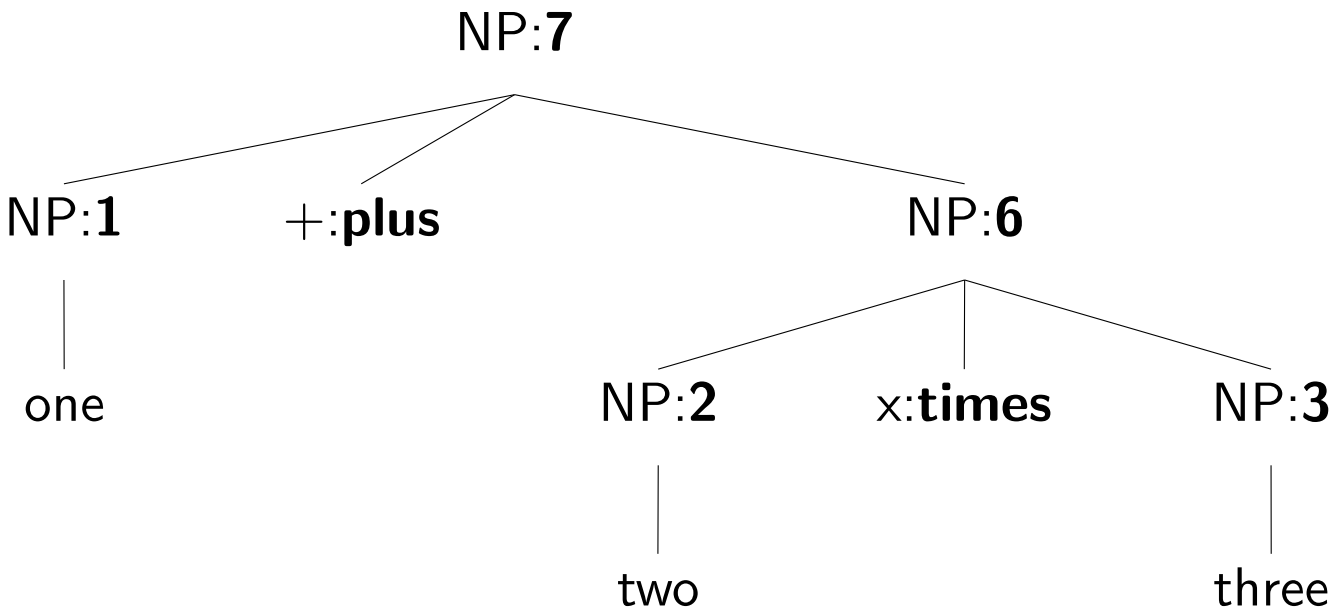



**p** = the individual who is the president at **l**
**T** = the set of Texans at **l**
Φ = the proposition that **p** is in the set **T**
= the function that maps a space-time location **l** to **true** just in case **p** is in **T** at **l** and to **false**, otherwise.

# Compositionality



# Compositionality



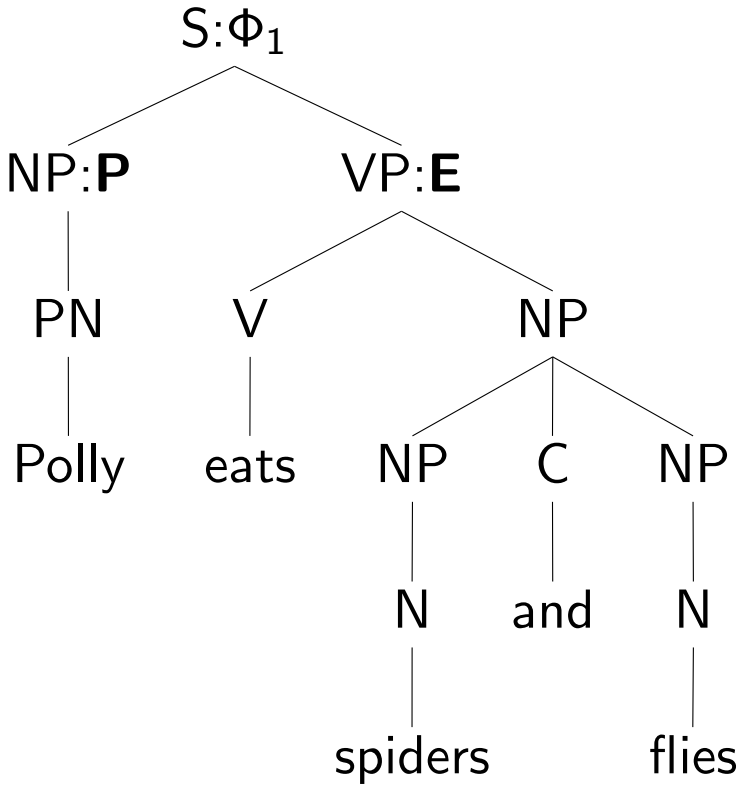
# Polly eats spiders and flies

- A meaning of **Polly eats spiders and flies**

  $\Phi_1$ = the proposition that Polly eats spiders and Polly eats flies, i.e.

- the function that maps a space-time location **l** to **true** just in case **Polly** is in the **eat** relation with both the set of **spiders** and the set of **flies**.

# Compositionality




**P** = **Polly**

**E** = the set of creatures that eat both spiders and flies.

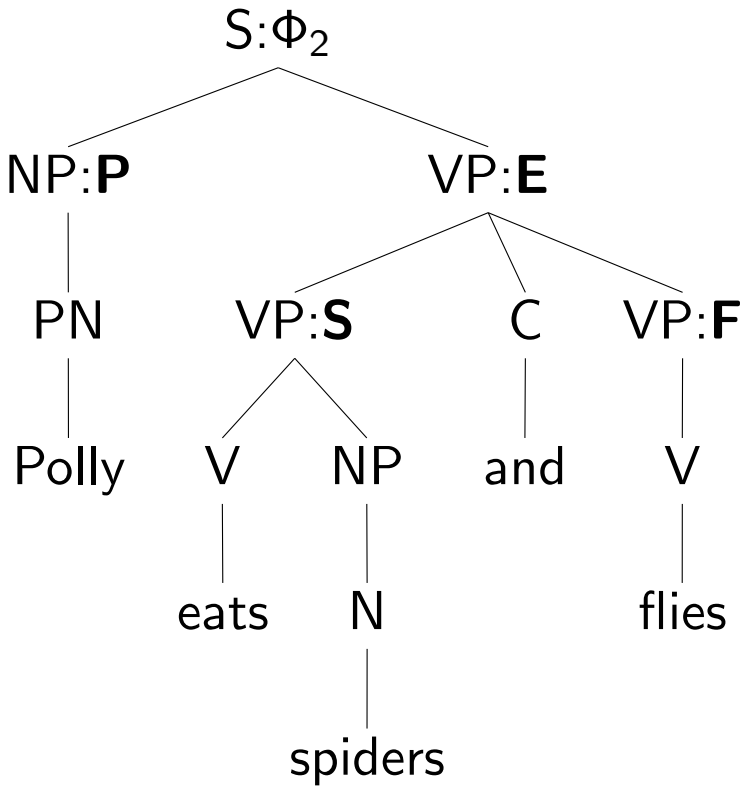
$\Phi_1$ = the proposition that **Polly** eats both spiders and flies = the function that maps a space-time location **l** to **true** just in case is in the set **E** at **l** and to **false**, otherwise.

# Polly eats spiders and flies

- A meaning of **Polly eats spiders and flies**

  $\Phi_2$ = the proposition that Polly eats spiders and Polly flies, i.e.
- the function that maps a space-time location **l** to **true** just in case **Polly** is in the **eat** relation with the set of **spiders** and **Polly** is in the set of things that **fly**.

# Compositionality




**P** = **Polly**
**S** = the set of creatures that eat spiders.
**F** = the set of creatures that fly.
**E** = ?

# Semantics and the Real World

- 'Formal' Semantics deals with the relation between language and the world.
- Truth conditions specify how changes in the world affect the truth of sentences.
- Some sentences have more than one set of truth conditions, corresponding to the fact that they are semantically (and possibly syntactically,) ambiguous.

# Entailment

Formal Semantics provides an account of **Entailment**:

- $\phi_1$ entails $\phi_2$ just in case any space-time location that makes $\phi_1$ true makes $\phi_2$ true.

  E.g.

- **Kim jogs with her dog** entails **Kim jogs**.
- **Kim jogs with her dog** entails **Kim has a dog**.
- **Kim jogs** entails **Kim runs**.
- **Kim does yoga and jogs** entails **Kim jogs**.
- **Kim does yoga and jogs** entails **Kim runs**.

# Systematic Relations among Word Meanings

**Synonymy**

**Hyponymy/Hypernymy**

**Antonymy**

**Polysemy**

**Homophony**

# Synonymy

**Synonym**: 'A word having the same or nearly the same meaning as another word or other words in a language.'

- automobile/car, $H_20$/water, cat/feline,...
- muskmelon/cantelope?
- Are there any true synonyms?

# Hyponymy (literally 'under-name')

**Hyponymy** is the relation between a more general and more specific word, a relation of inclusion.

- If you can say **all Xs are also Ys** then this means **X is a hyponym of Y**
- The opposite relation is that Y is a superordinate of X (also called **hypernym** 'above-name').

  vehicle/car, plant/flower/tulip,..

- **Antonymy**

  Complementary antonyms: alive/dead, mortal/immortal, married/unmarried...

  Gradable antonyms: tall/short, big/little,...

  Relational antonyms (converses): parent/child, teacher/student, buy/sell...

# Systematic Relations among Word Meanings

- **Synonymy**: $A$ and $B$ are synonyms if for any space-time location $\mathbf{l}$, $\mathbf{S}_A$ at $\mathbf{l} = \mathbf{S}_B$ at $\mathbf{l}$
- **Hyponymy**: If $B$ B is a hyponym of $A$, then for any space-time location $\mathbf{l}$, $\mathbf{S_B}$ at $\mathbf{l}$ is a proper subset of $\mathbf{S_A}$ at $\mathbf{l}$.

  (And then $A$ is a hypernym of $B$.)
- **Antonymy**: $A$ and $B$ are antonyms if
  - there is some appropriate domain $D$ such that for any space-time location $\mathbf{l}$,
  - $\mathbf{S}_A$ at $\mathbf{l} \cup \mathbf{S}_B$ at $\mathbf{l} = \mathbf{S}_D$ at $\mathbf{l}$, and
  - $\mathbf{S}_A$ and $\mathbf{S}_B$ are disjoint at $\mathbf{l}$.

# Lexical Semantic Relations as Meaning Postulates

- For all space-time locations **l**, the reference of *sedan* at **l** is a subset of the reference of *car* at **l**.
- For all locations **l**, the reference of *car* at **l** is a subset of the reference of *vehicle* at **l**.
- There are no locations where the reference of *awake* overlaps with the reference of *asleep*.

- At every space-time location, the reference of *bachelor* is included in (is a subset of) the reference of *male*.
- At every location, the reference of *bachelor* is included in (is a subset of) the reference of *unmarried*.

# Lexical Semantic Relations as Entailments

- **Kim is a bachelor.** entails **Kim is male.**
- **Pat owns a station wagon.** entails **Pat owns a vehicle.**
- **Bo is awake.** entails **Bo is not asleep.**
- **Chris killed Dana.** entails **Dana is dead.**
- **Terry gave Bo a book.** entails **Bo got/has a book.**
- **Terry managed to read Plato.** entails **Terry read Plato.**
- **Terry failed to read Plato.** entails **Terry didn't read Plato.**
- ...

# Polysemy:

A single word is **polysemous** if it has several meanings that are related in some way:

- pig (the animal) and pig ('sloppy person')
- pool (of water on the ground) and (swimming) pool
- $\text{bank}_2$ ('financial institution') and $\text{bank}_3$ ('a similar institution') [blood bank; egg bank; sperm bank]

- Generally speaking, some adjectives are **gradable** while others are not.
- Gradable properties can be said to exist to a degree (unlike **complementary** properties.
- The simplest test for **gradable** adjectives is whether you can modify the word with very.

  **Gradable**: very large/very small; very sad/very happy; very wet/very dry

  **Nongradable**: *very first/*very last; *very alive/*very dead; *very single/*very married.

# Differing Entailments: **all** vs. **no**

- 'All Texans [vote republican and eat steak]' entails 'All Texans vote republican'
- 'All Texans [eat sirloin steak]' entails 'All Texans eat steak'.
- 'No Texans [vote republican and eat steak]' does not entail 'No Texans vote republican'
- 'No Texans [eat sirloin steak]' does not entail 'No Texans eat steak'.

# Differing Entailments: **all** vs. **no**

- 'All Texans vote republican' does not entail 'All Texans [vote republican and eat steak]'.
- 'All Texans eat steak' does not entail 'All Texans [eat sirloin steak]'.
- 'No Texans vote republican' entails 'No Texans [vote republican and eat steak]'.
- 'No Texans eat steak' entails 'No Texans [eat sirloin steak]'.

# Two classes of Determiners

- **all**, **most**, **at least n**,... are **upward entailing** – the inference from the subset to the superset is valid:

  'All Texans [eat sirloin steak]' entails 'All Texans eat steak'.
- **no**, **few**, **at most n**,... are **downward entailing** – the inference from the superset to the subset is valid:
- 'No Texans eat steak' entails 'No Texans [eat sirloin steak]'.

# Structural Ambiguity 1

- **Attachment Ambiguity:**

  I forgot how good beer tastes.

  I saw the man with the telescope.

- **Verb Class Ambiguity:**

  Teddy is the man that I want to succeed.

  They gave away the letter to Jones.

# Structural Ambiguity 2

- **Complement vs. Adjunct Ambiguity:**

  I found the boy hopping on one foot.

  I can't see wearing my eyeglasses.

- **Coordination Ambiguity:**

  This offer applies to old men and women.

  Every husband and father should pay attention to this.

# Lexical Ambiguity

- **Category Ambiguity:**

  a draft/to draft; a can/to can

- **Polysemy:**

  I want a light beer.

  It must be tough to lose a wife.
  (-Yes, practically impossible.) [Groucho Marx, 1961]

# More Lexical Ambiguity

- **Homophony:**

  They can build a better pen.

  She kicked the bucket.

  That man is mad.

# Interactions

- In addition, there are many interactions of these ambiguities which involve both structural and lexical ambiguity:

  I saw her duck.

  The only thing capable of consuming this food has four legs and flies. [M.A.S.H. rerun]

  I saw that gas can explode.

  I can have any guy I please (unfortunately I don't please any of them). [Lily Tomlin]

# Ambiguity of Scope:

Jones has found a defect in every Toyota with over 100,000 miles.

Dukakis agrees to only two debates. (SF Chronicle, 1988)

Everyone in the room speaks at least two languages.

# Quantifiers

Everyone in the room speaks at least two languages.

**For every person in the room there are at least two languages** such that the person speaks the language.

**(for every person in the room x)** [**(there are at least two languages y)** such that **x** speaks **y**].

**(there are at least two languages y)** such that [**(for every person in the room x) x** speaks **y**].

# Ambiguity of Ellipsis:

Jan likes Dana more than Lou __ .

Nothing makes you feel as good as gold.
[Jewelry commercial-1988]

Jones thought the yacht was longer than it is.
[Bertrand Russell]

McCain claims he'll solve all the world's problems more often than Edwards does __ .
[Strict vs. 'Sloppy' Identity]

# Ambiguity and Ellipsis:

Kim likes visiting relatives.

Kim likes visiting relatives more than I do __ .

**Ellipsis preserves meaning (and can disambiguate).**

Someone in the class interviewed each candidate.

Someone in the class interviewed each candidate. Pat did __ , too.