Semantics

Language LING UA 1, NYU, Summer 2018

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partially based on the teaching materials by Masha Esipova and Lucas Champollion
for Introduction to Semantics LING-UA 4 at NYU in Fall 2017

What is semantics?

What is semantics?

Semantics is:

- the part of grammar that represents a speaker’s knowledge of how to interpret the meaning of linguistic expressions (words and phrases)
- the subfield of linguistics that studies this knowledge

Compositional semantics

Compositional semantics

Remember our toy lexical entry for *wombat*?

wombat	phonology:	/ˈwɑmˌbæt/
	syntax:	noun
	semantics:	{x | x is a wombat}
	concept:	

Lexical semantics is concerned with meanings of individual words as stored in the lexicon and relationships between them.

Compositional semantics

But what about the expressions below, how do we figure out what they mean?

- a grey wombat
- a large grey wombat
- a large grey combat wombat named Lambda

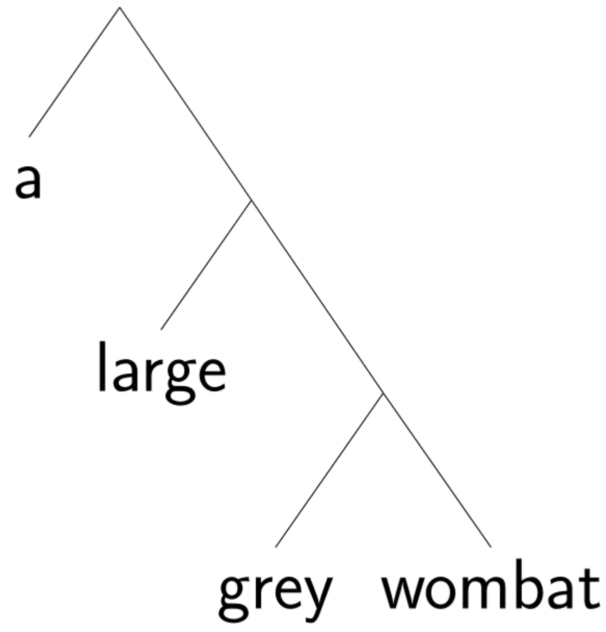
We can’t possibly store their meanings in the lexicon.

Compositional semantics is concerned with how we compute meanings of complex linguistic expressions based on the meanings of their parts and the rules used to combine them.

We will mostly focus on compositional semantics in this course.

Compositional semantics

In compositional semantics we assume that we read semantic structure off syntactic trees.



Truth conditions

What do sentences mean?

What do you know when you know what a sentence means?

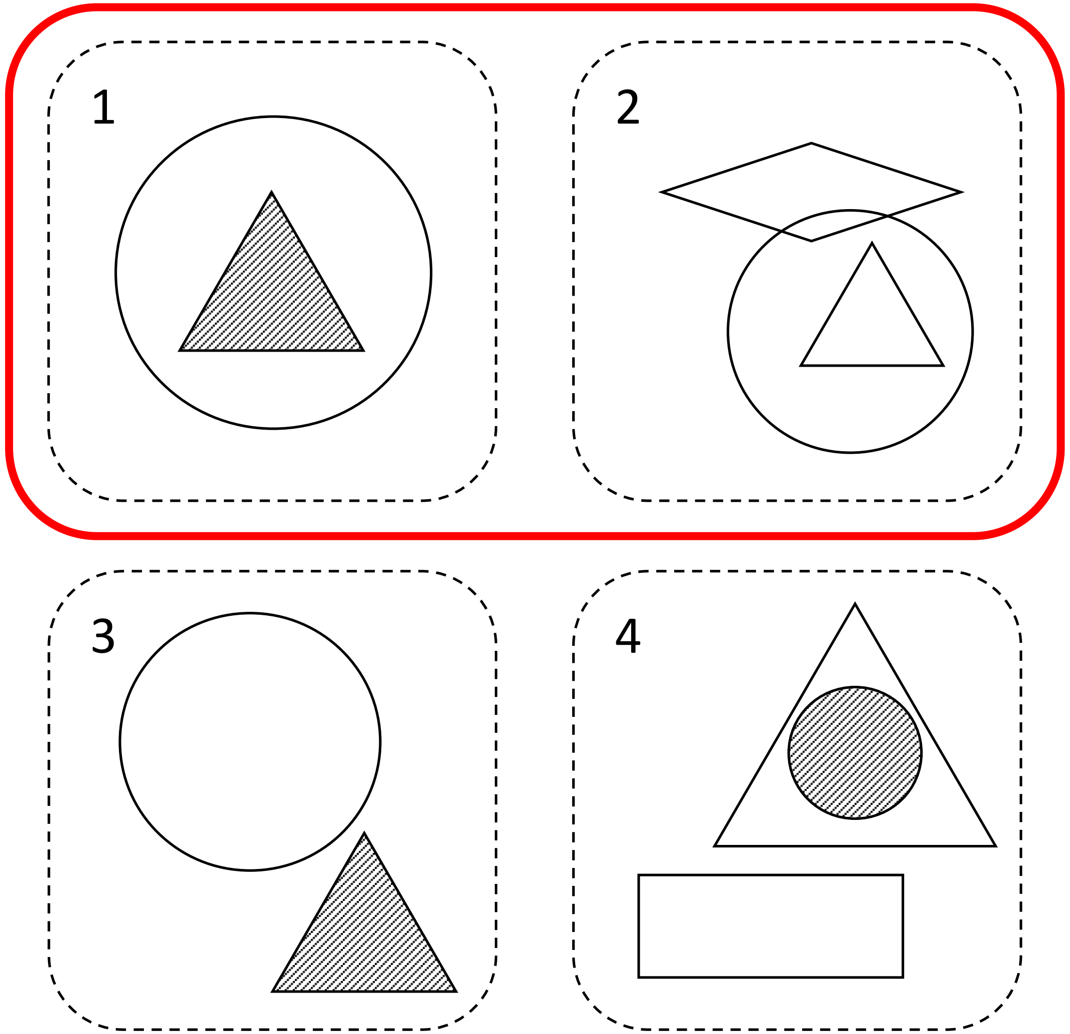
In-class Exercise 1

Draw a scenario T in which (1) is true and another one, F, in which it is false (both should contain a single triangle and a single circle, and *inside* should be understood as ‘completely inside’).

(1) The triangle is inside the circle.

Now add a few more scenarios to your drawing, different from your original scenarios T and F and from each other (for example, they can contain other figures), such that they all contain a single triangle and a single circle, but in some of them (1) is true and in some of them it’s false. Circle the “true set”.

Truth conditions



Truth conditions

Our little drawing exercise relies on the idea that if you know what a sentence means, you know in which scenarios it’s true and in which it’s false, i.e., you know its **truth conditions**.

It’s important to distinguish truth conditions from **truth values**.

Do you know the truth value of the sentence in (2)? Do you know its truth conditions?

(2) It was raining in Saint Petersburg on August 23, 1989 at 6am.

Propositions

We can think of the scenarios we drew in Exercise 1 as partial depictions of **possible worlds**.

We can then model **denotations** (i.e., meanings) of **declarative sentences** as sets of possible worlds in which those sentences are true. E.g., the sentence *The triangle is inside the circle* denotes the set of all possible worlds in which this sentence is true.

We call such sets of possible worlds **propositions**. Declarative sentences denote propositions.

Propositions

Why think of meanings of sentences as sets of worlds?

Reason 1. To capture the meaning of **logical connectives**, such as *and*, *or*, and *not*.

Propositions

In-class Exercise 2

Go back to your drawings from In-class Exercise 1 and shade some of the triangles in the “true set” and in the “false set”.

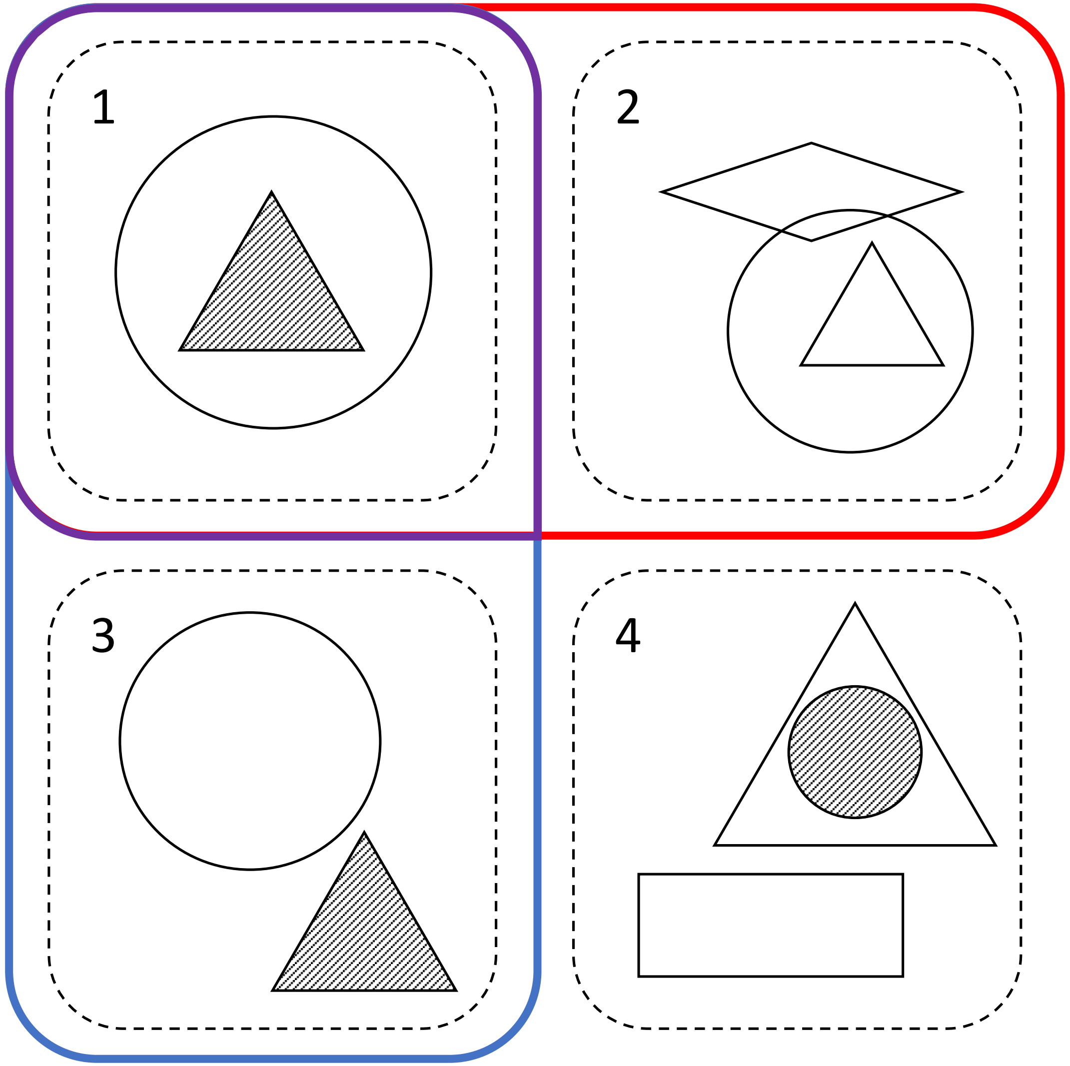
Now identify the scenarios in which the sentence in (5) is true.

(3) The triangle is inside the circle.

(4) The triangle is shaded.

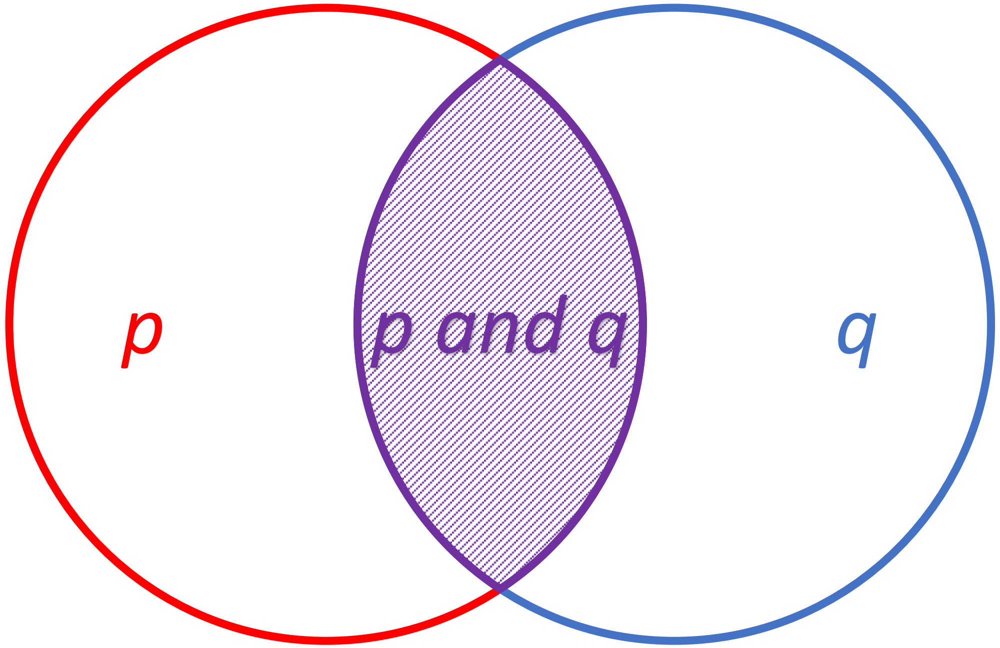
(5) The triangle is inside the circle and the triangle is shaded.

Propositions



Propositions

Logical connectives perform operations on sets. E.g., we can model **conjunction** of any declarative sentences *p* and *q* as the **intersection** of the sets they denote.



Propositions

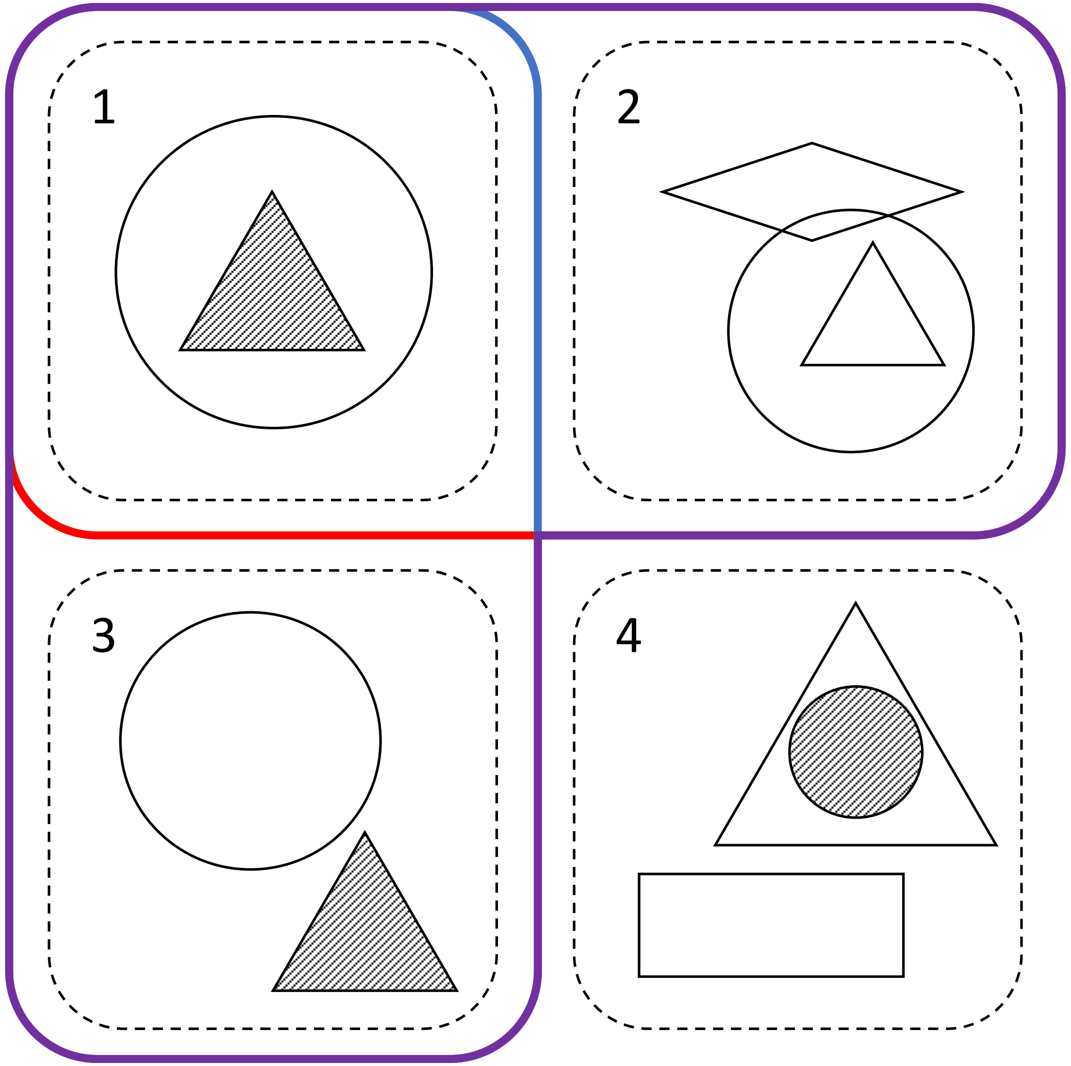
What about **disjunction**? How do we model disjunction via sets?

Think about when the following sentence is true:

(6) The triangle is inside the circle or the triangle is shaded.

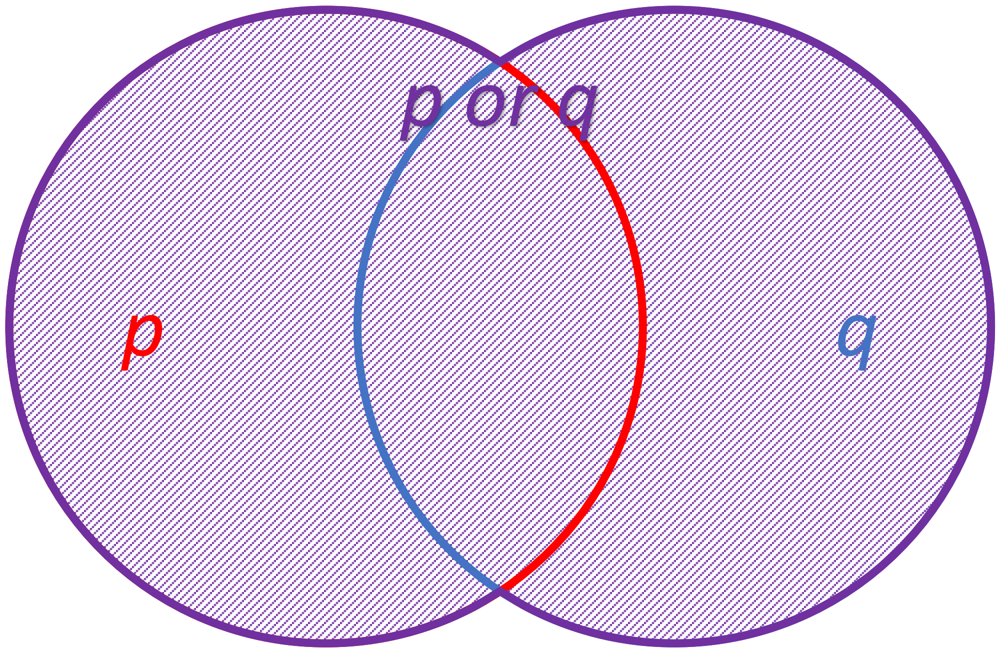
If you think (6) is true only in scenarios 2 and 3, you're interpreting *or* as **exclusive disjunction**. If you think (6) is also true in scenario 1, you're interpreting *or* as **inclusive disjunction**.

We will assume that English *or* is inclusive.



Propositions

We can model disjunction of *p* and *q* as the **union** of the sets they denote.



Propositions

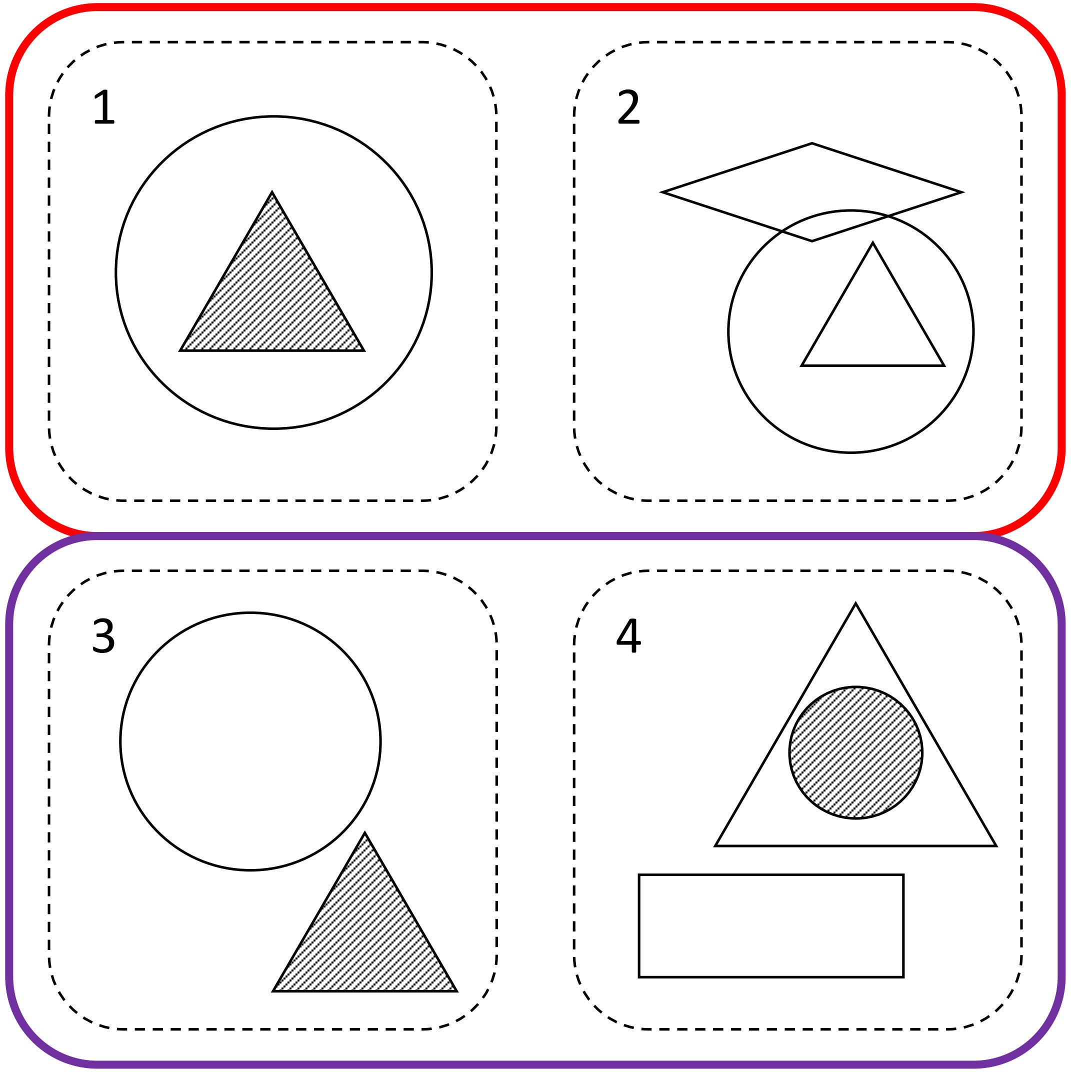
Now what about **negation**? How do we model negation via sets?

Think about when the following sentence is true:

(7) The triangle isn't inside the circle.

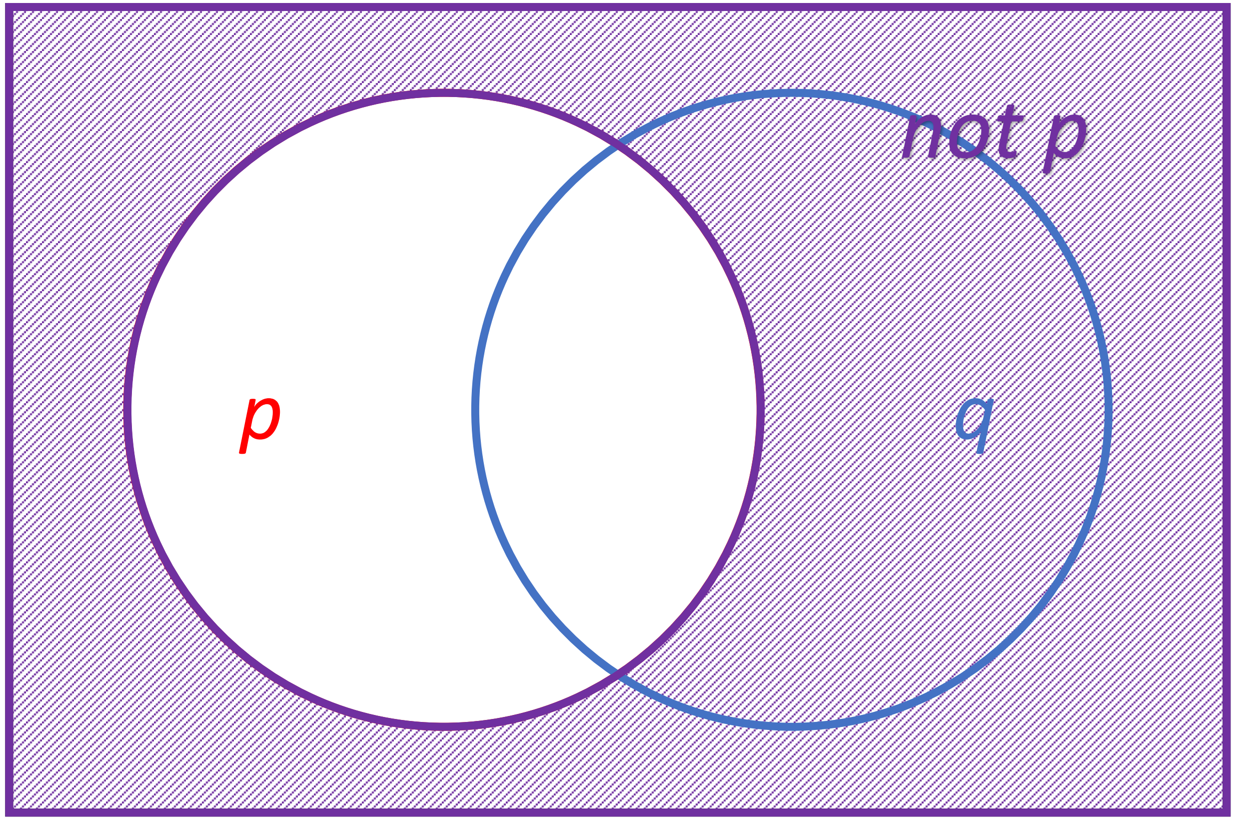
(It's not the case that the triangle is inside the circle.)

It's true in scenarios 3 and 4, i.e., all the scenarios outside of the set denoted by *The triangle is inside the circle*.



Propositions

We can model negation of *p* as the **absolute complement** of the set it denotes.



Propositions

Why think of meanings of sentences as sets of worlds?

Reason 1. To capture the meaning of **logical connectives**, such as *and*, *or*, and *not*.

Reason 2. To capture intuitive relationships between sentences, such as **entailment** or **contradiction**.

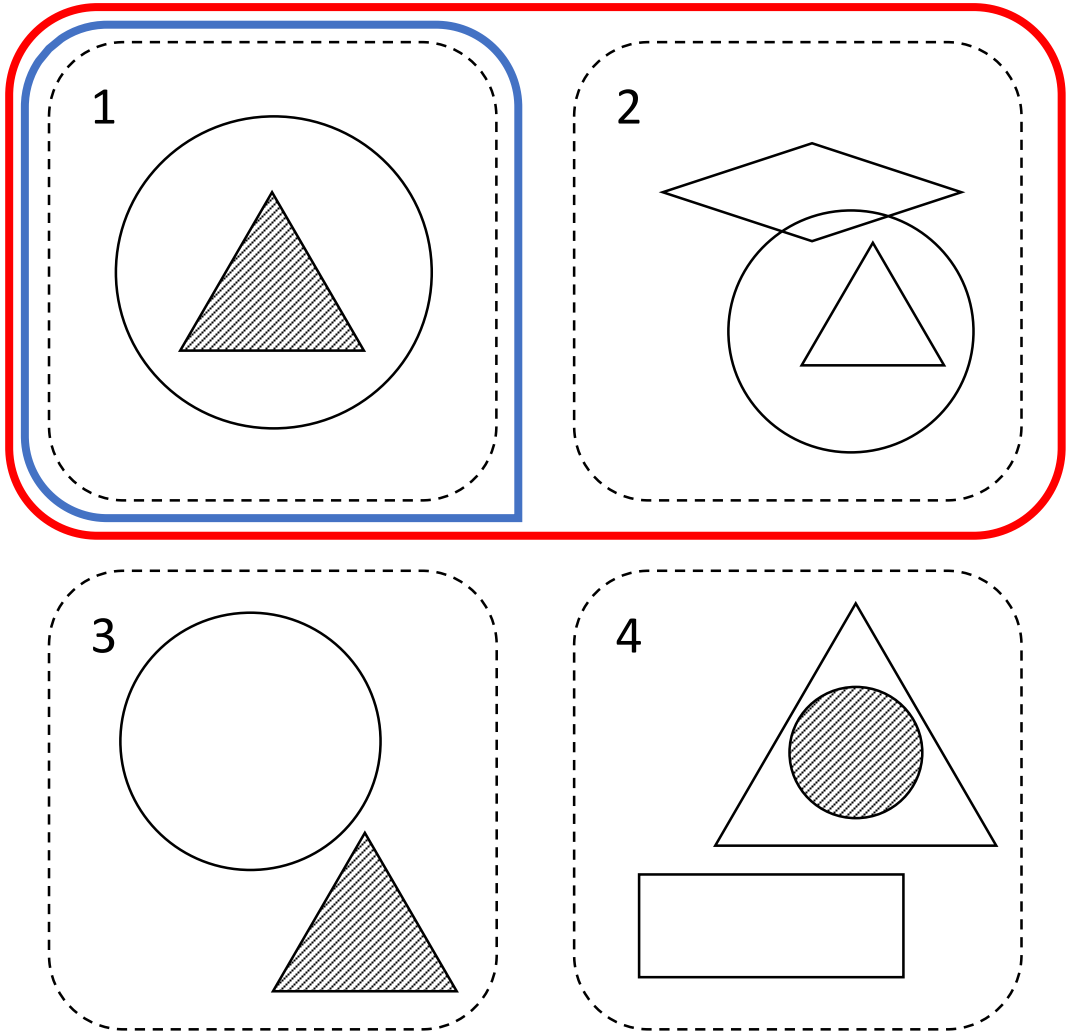
Propositions

Whenever (9) is true, (8) is also true. We say that (9) **entails** (8).

(8) There is a triangle inside the circle.

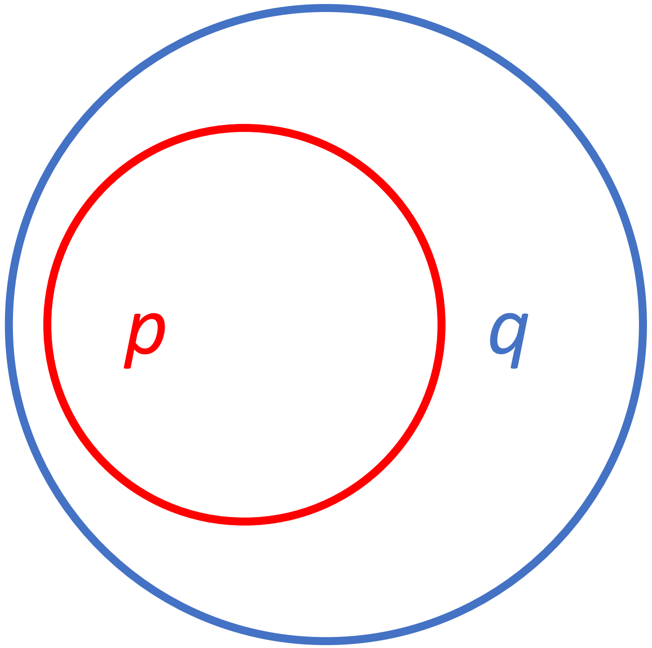
(9) There is a shaded triangle inside the circle.

(9) is true in a subset of the scenarios in which (8) is true.



Propositions

We model an entailment relationship between p and q as a **subsethood** relationship between the sets that they denote. If p entails q (written as $p \rightarrow q$), the set denoted by p is a subset of the set denoted by q.



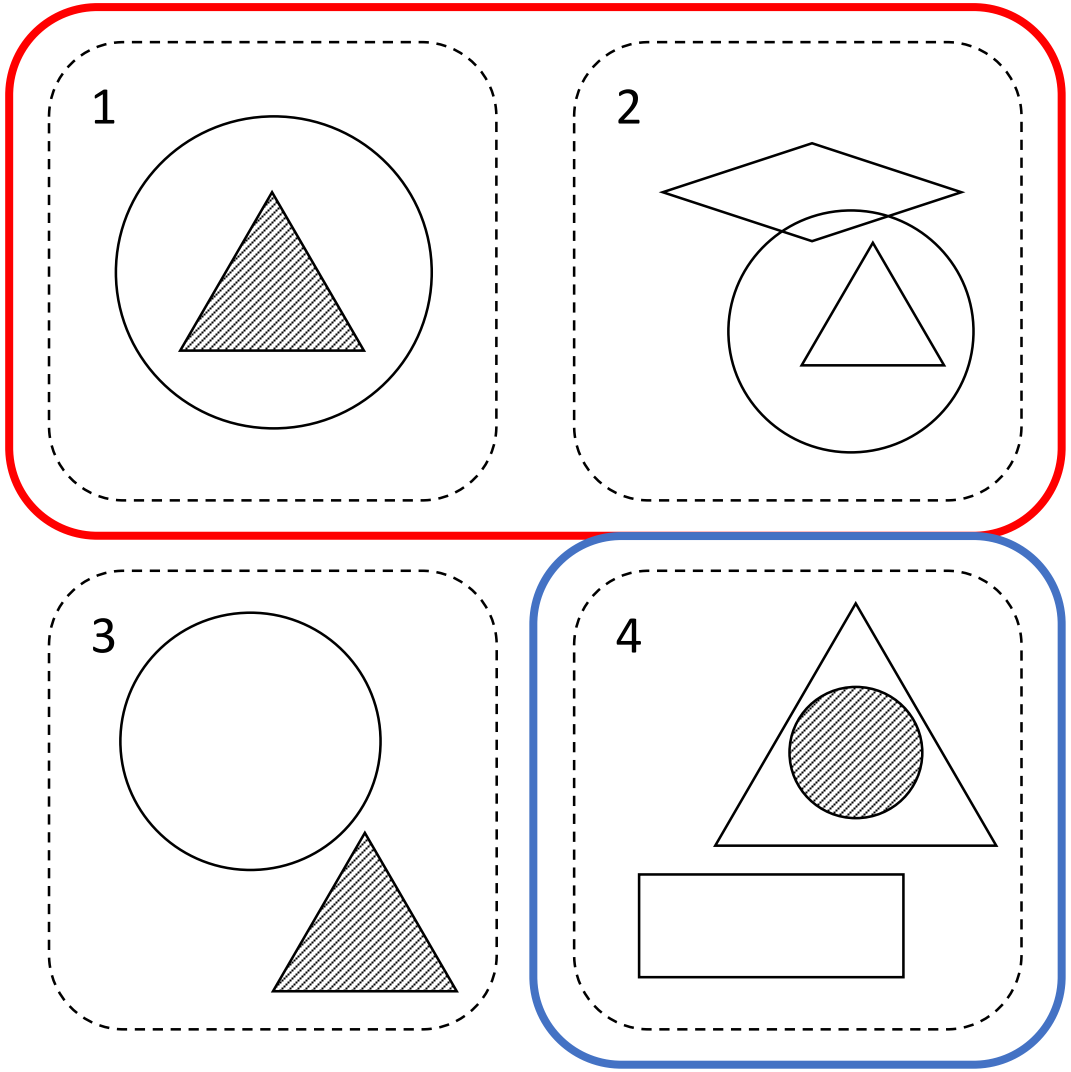
Propositions

Whenever (10) is true, (11) is false (and vice versa). We say that (10) and (11) **contradict** each other.

(10) The triangle is inside the circle.

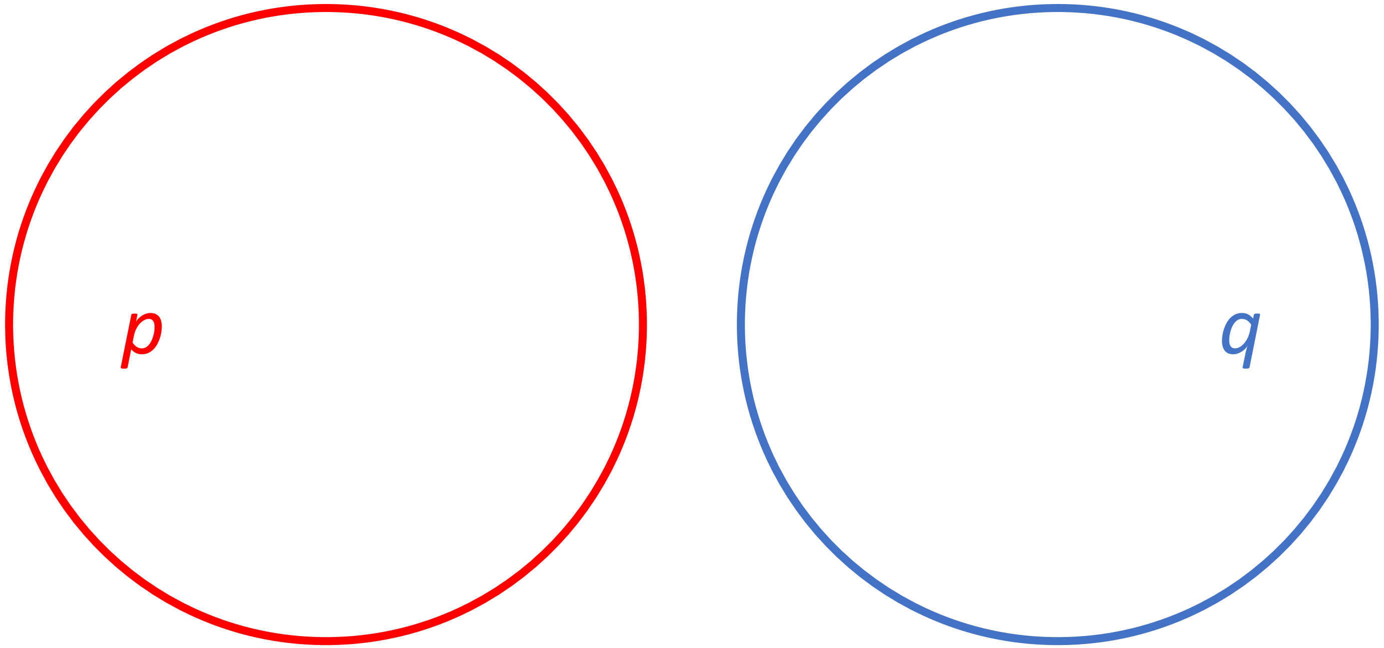
(11) The circle is inside the triangle.

There are no scenarios in which both (10) and (11) are true.



Propositions

We model a contradiction relationship between *p* and *q* as a **disjointness** relationship between the sets that they denote. If *p* and *q* contradict each other, the sets they denote are disjoint.



Propositions

Why think of meanings of sentences as sets of worlds?

Reason 1. To capture the meaning of **logical connectives**, such as *and*, *or*, and *not*.

Reason 2. To capture intuitive relationships between sentences, such as **entailment** or **contradiction**.

Reason 3. To model beliefs and belief updates, desires, etc. via possible worlds. E.g., imagine you don't know if (2) is true.

(2) It was raining in Saint Petersburg on August 23, 1989 at 6am.

The set of worlds compatible with your beliefs will contain both the worlds in which it was raining in SPb on 8/23/1989 at 6am, and those in which it wasn't. What happens if I utter (2) (and you believe me)?

Propositions

How do sentences like (12) and (13) fit into the picture?

(12) Who drank the potion?

(13) Drink the potion!

We can think of **questions** as denoting sets of propositions (i.e., sets of sets of worlds!) that can serve as answers to those questions. What would the denotation of (12) be then?

We can think of **imperatives** as denoting sets of “satisfactory” or “desirable” worlds according to the speaker. What would the denotation of (13) be then?

In-class practice I

Assume *p*, *q*, and *r* are declarative sentences logically independent from one another. Draw a diagram for each sentence *S* below. Represent the set of all possible worlds as a rectangle and the propositions denoted by *p*, *q*, and *r* as overlapping circles within this rectangle. No need to draw the possible worlds themselves. Shade the areas in which *S* is true.

- *p and q and r*
- *p and not q*
- *(p and q) or r*
- *p and (q or r)*

Baby set theory

Sets are abstract unordered collections of distinct objects:

(14) $\{2, 4, 11\}$

(15) $\{4, 2, 11\}$

Because sets are unordered, (14) and (15) are the same set.

The objects in a set are called **members** or **elements** of that set:

(16) $2 \in \{2, 4, 11\}$

(17) $3 \notin \{2, 4, 11\}$

Anything can be an element of a set, including other sets:

(18) {8, {π, Hermione}, Harry, ◊}

Baby set theory

A set can be **infinite**:

(19) {1, 3, 5, 7, …}

Singleton sets contain only one element:

(20) {6}

The **empty set** contains no elements; the common notation for the empty set is:

(21) {}

or

(22) Ø

Baby set theory

The **cardinality** of a set is the number of elements it contains:

(23) |{5, 0, Hermione}|= 3

Sometimes we can’t list all the elements of the set, because there are too many of them, or because we don’t know what they all are. But as long as we know the unique distinctive feature of a given set, we can use **predicate notation** to describe that set:

(24) {Drogon, Rhaegal, Viserion, Smaug, …}

(25) {x | x is a dragon}

Baby set theory

One set can be a **subset** of another:

(26) $\{9, 11\} \subseteq \{9, 11, 13\}$

(27) $\{9, 10\} \not\subseteq \{9, 11, 13\}$

Formal definition of subsethood:

(28) $A \subseteq B$ iff for all x : if $x \in A$, then $x \in B$

($A \subseteq B$ is true if and only if every element of A (if any) is also an element of B)

The empty set is a subset of every set.

Baby set theory

By the definition in (28), every set is a subset of itself. If *A* is a subset of *B*, but not equal to it, *A* is a **proper subset**:

(26) $\{9, 11\} \subset \{9, 11, 13\}$

(27) $\{9, 11, 13\} \not\subset \{9, 11, 13\}$

Formal definition of proper subsethood:

(31) $A \subset B$ iff $A \neq B$ and for all x : if $x \in A$, then $x \in B$

Question: is the empty set a proper subset of every set?

Baby set theory

The reverse of subset is **superset**. Supersets can be proper, too.

(32) $\{42, 3, 11\} \supset \{42, 3\}$

(33) $\{42, 3, 11\} \supseteq \{42, 3, 11\}$

(34) $\{42, 3, 11\} \not\supset \{42, 3, 11\}$

Baby set theory

The **intersection** of *A* and *B*, written $A \cap B$, is the set of all entities *x* such that *x* is an element of *A* and *x* is an element of *B*:

(35) $\{w, x, y\} \cap \{x, y, z\} = \{x, y\}$

If the intersection of two sets is empty, those two sets are called **disjoint**.

The **union** of *A* and *B*, written $A \cup B$, is the set of all entities *x* such that *x* is an element of *A* or *x* is an element of *B*, e.g.:

(36) $\{w, x, y\} \cup \{x, y, z\} = \{w, x, y, z\}$

Baby set theory

We can also subtract one set from another. The **difference** of *A* and *B*, written $A - B$ or $A \setminus B$, is the set of all entities *x* such that *x* is an element of *A* and *x* is not an element of *B*:

(37) {w, x, y, z} – {v, x, y} = {w, z}

The result of subtracting *A* from *B* is often called the **complement set** of *B* relative to *A*. The **absolute complement** of *A*, sometimes written A', is the set of all things that are not elements of *A*.

Baby set theory

We model:

- conjunction (*and*) as intersection
- disjunction (*or*) as union
- negation (*not*) as difference (*not p* denotes the absolute complement of the set denoted by *p*)

In-class practice II

What is the cardinality of each of the following sets?

- $\{13, \emptyset\}$
- $\{404, \{7, 66, 1\}\}$
- $\{a, b, b, c\}$
- $\{a, \{b\}, b, c\}$

Are the following statements true?

- $\{3, 3, 2\} = \{3, 2\}$
- {Drogon, {Viserion}} = {Drogon, Viserion}
- $\{\emptyset\} = \emptyset$
- $\{d, f\} \subseteq \{f, e, d\}$
- $\emptyset \subseteq$ {Smaug, 14}
- $\emptyset \in$ {Smaug, 14}
- $\{6, 9\} \not\subseteq \{6, \{9\}, 7\}$

Predication

We said that in compositional semantics we get to a sentence’s meaning from the meanings of its parts.

But so far we’ve only looked at parts of sentences that are themselves sentences.

We will now look at simple sentences like this:

(37) Hermione hikes.

(38) Neville hikes.

We know what it takes for (37) and (38) to be true, but how do we know it?

Predication

Both (37) and (38) consist of a subject NP (*Hermione* and *Neville*, respectively) and a VP *hikes* (we will ignore tense in this module). What do these parts mean and how do we combine them?

Hermione and *Neville* are **names**, which simply denote—or **refer** to—the **individuals** (or **entities**) thus named.

One-place predicates like *hikes* denote **properties**. We can think of properties as unsaturated propositions that take an individual argument to **saturate** them.

But how do we model properties?

Predication

Extensional approach: ignore multiple possible worlds and model properties as sets of individuals that have a certain feature in a given world. E.g., the **extension** of *hikes* is the set of all hikers in the world of evaluation.

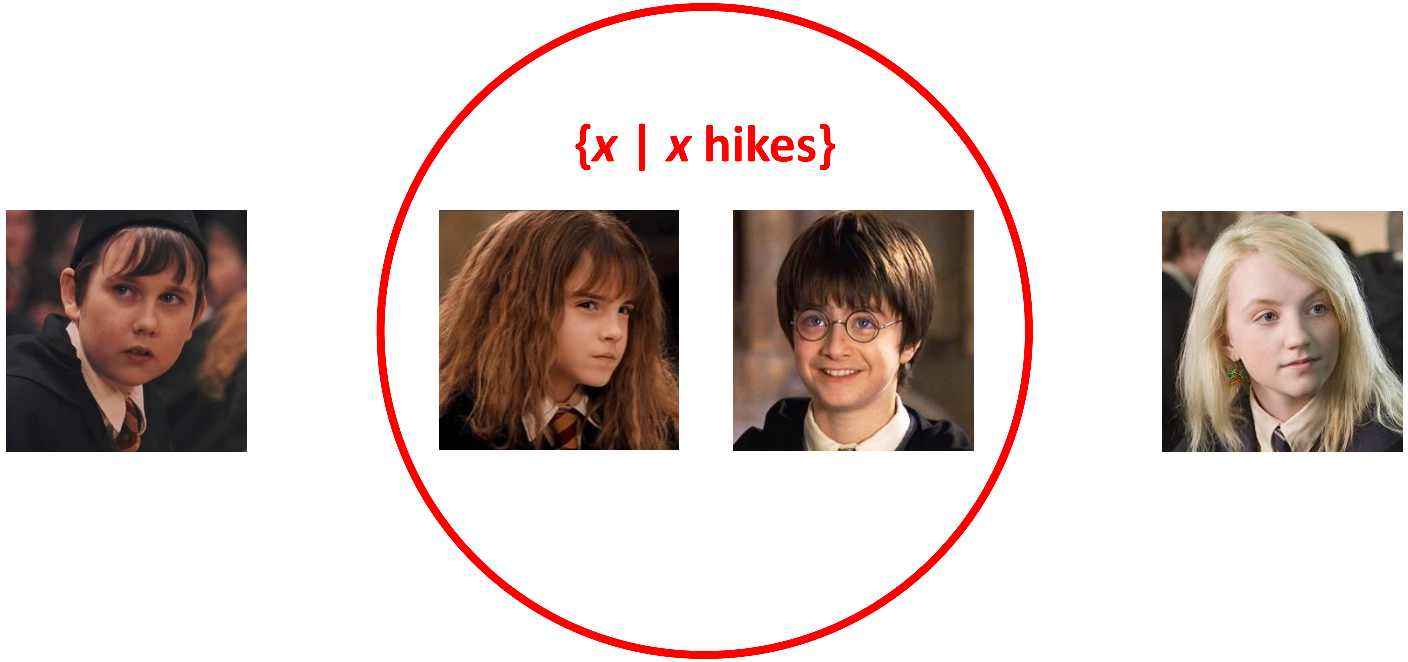
Intensional approach: keep in mind multiple possible worlds and model properties as associations between worlds and sets of individuals. E.g., the **intension** of *hikes* is an association between possible worlds and the sets of all hikers in those worlds.

In this class we will stick with the extensional approach to things that are not propositions for simplicity.

Predication

The sentence of the form *x hikes* is true in the world of evaluation w_0 iff *x* is a member of the set of individuals that hike in w_0.

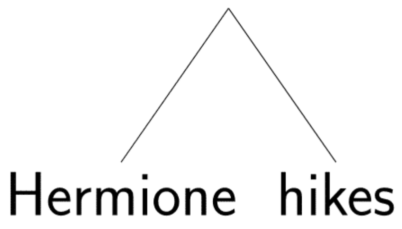
Thus, if the scenario below is a partial depiction of w_0, *Hermione hikes* is true in w_0 and *Neville hikes* is false. What about *Harry hikes* and *Luna hikes*?



Predication

Deriving *Hermione hikes* compositionally:

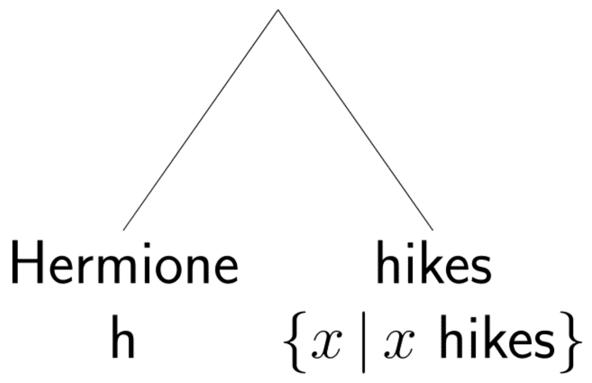
- Draw a simplified tree of the sentence.



Predication

Deriving *Hermione hikes* compositionally:

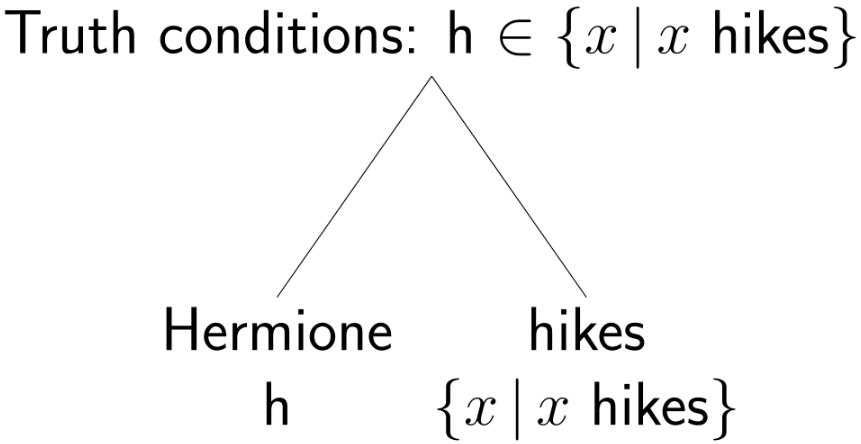
- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node, in predicate notation where relevant. (We write h for the individual Hermione so as not to confuse names with their referents.)



Predication

Deriving *Hermione hikes* compositionally:

- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node, in predicate notation where relevant. (We write h for the individual Hermione so as not to confuse names with their referents.)
- Write the truth conditions of the entire sentence in set theoretical notation.



Predication

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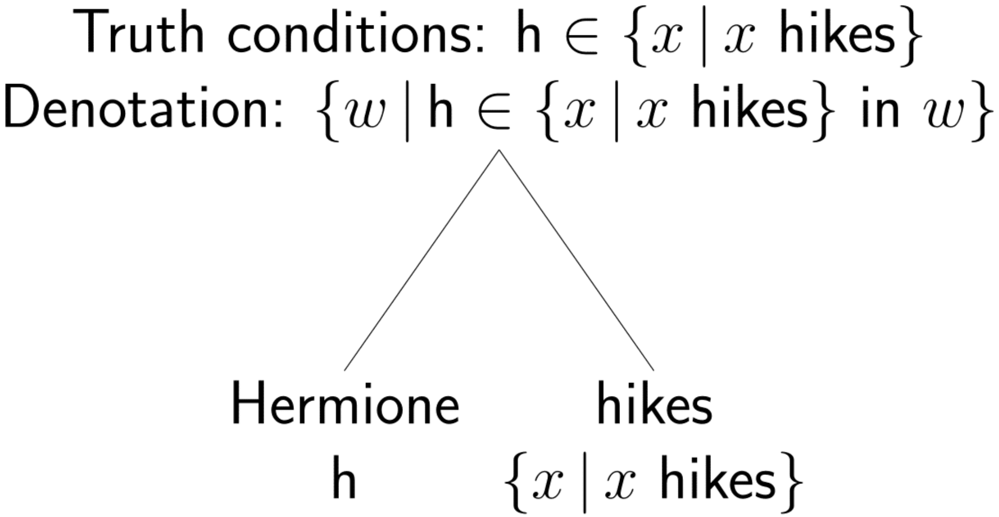
- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node, in predicate notation where relevant. (We write h for the individual Hermione so as not to confuse names with their referents.)
- Write the truth conditions of the entire sentence in set theoretical notation.
- Write the denotation of the entire sentence as a proposition in set theoretical notation.



Predication

Now what about sentences with **adjectival predicates**, as in (39)? In particular, what does the copula *is* in (39) mean (putting aside tense), if *smart* also denotes a property?

(39) Hermione is smart.

Two options:

- The role of the copula is purely syntactic, it's not interpreted by the semantics.
- The copula has a meaning, but a trivial one (takes a property and returns the same property).

Either way, we can ignore the copula and treat (39) in the same way as *Hermione hikes*.

Predication

What about sentences with **nominal predicates**, as in (40)? Is the indefinite article *a* also meaningless/trivial?

(40) Hermione is a hiker.

When *a* is in an NP in an argument position, it seems to be non-trivially meaningful:

(41) A hiker fell.

(42) The/every/no/… hiker fell.

Our options:

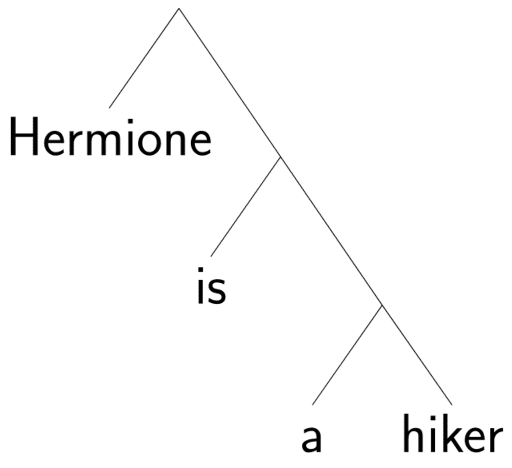
- Lexical ambiguity: there are two different *a's*, one meaningless, one meaningful.
- *A* is meaningless in both cases; in (41) it indicates absence of *the*, *every*, *no*, etc.
- *A* is meaningful in both cases, but nouns aren't born as properties; in (40) *a* combines with *hiker* to yield a property.

We'll set this question aside and will treat *a* in nominal predicates as vacuous.

Predication

Deriving *Hermione is a hiker* compositionally:

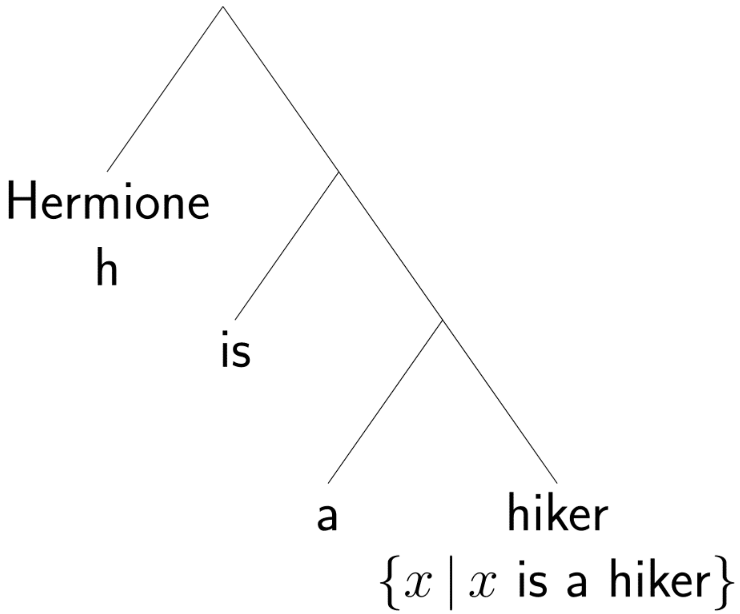
- Draw a simplified tree of the sentence.



Predication

Deriving *Hermione is a hiker* compositionally:

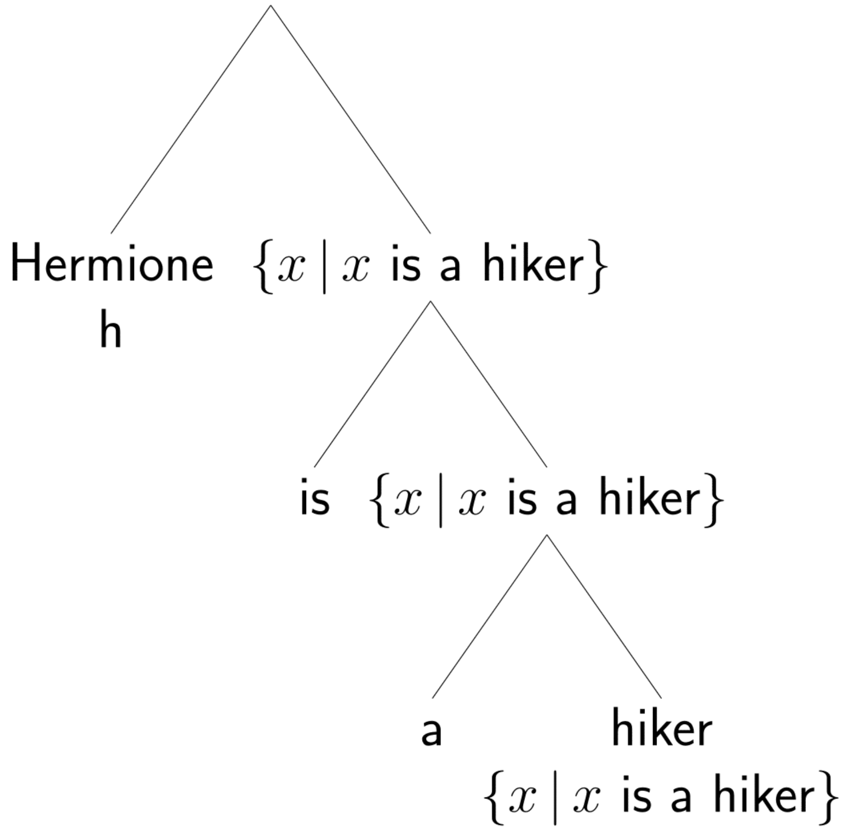
- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.



Predication

Deriving *Hermione is a hiker* compositionally:

- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.
- Write denotations (extensions) of each non-terminal non-root node, treating *is* and *a* as vacuous.



Predication

Deriving *Hermione is a hiker* compositionally:

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- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.
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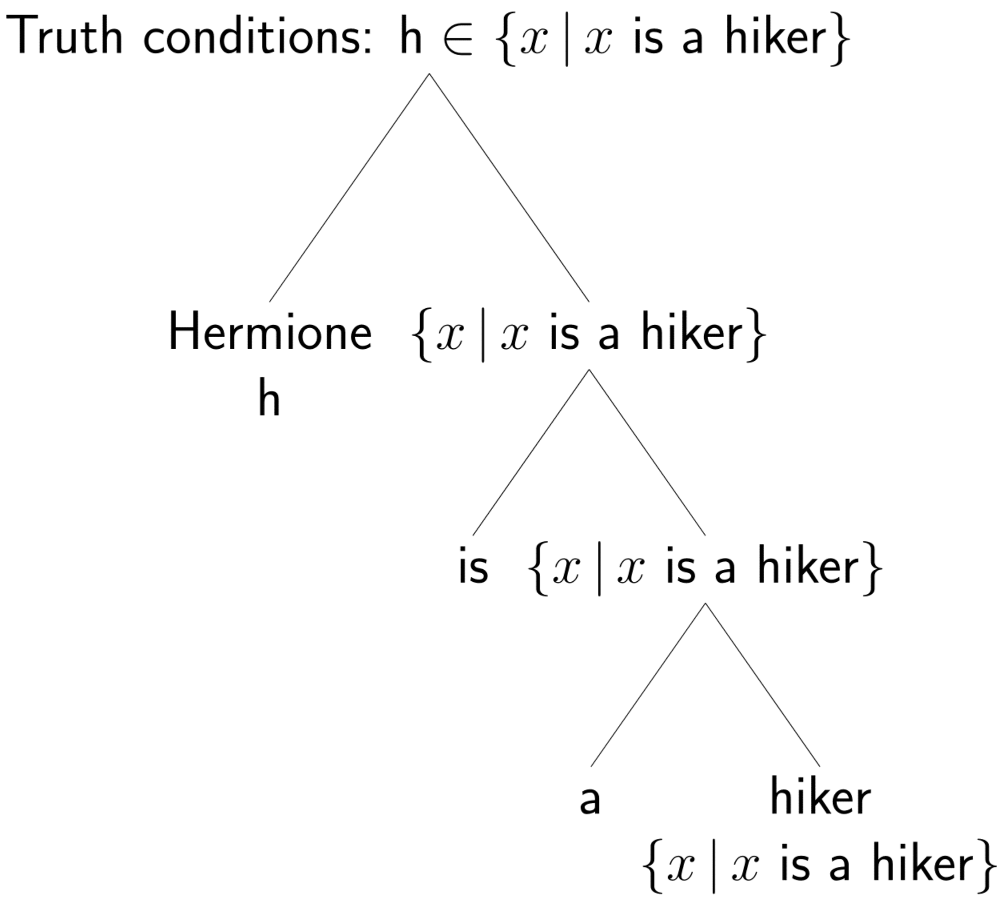

Predication

Deriving *Hermione is a hiker* compositionally:

- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.
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- Write the truth conditions of the entire sentence in set theoretical notation.
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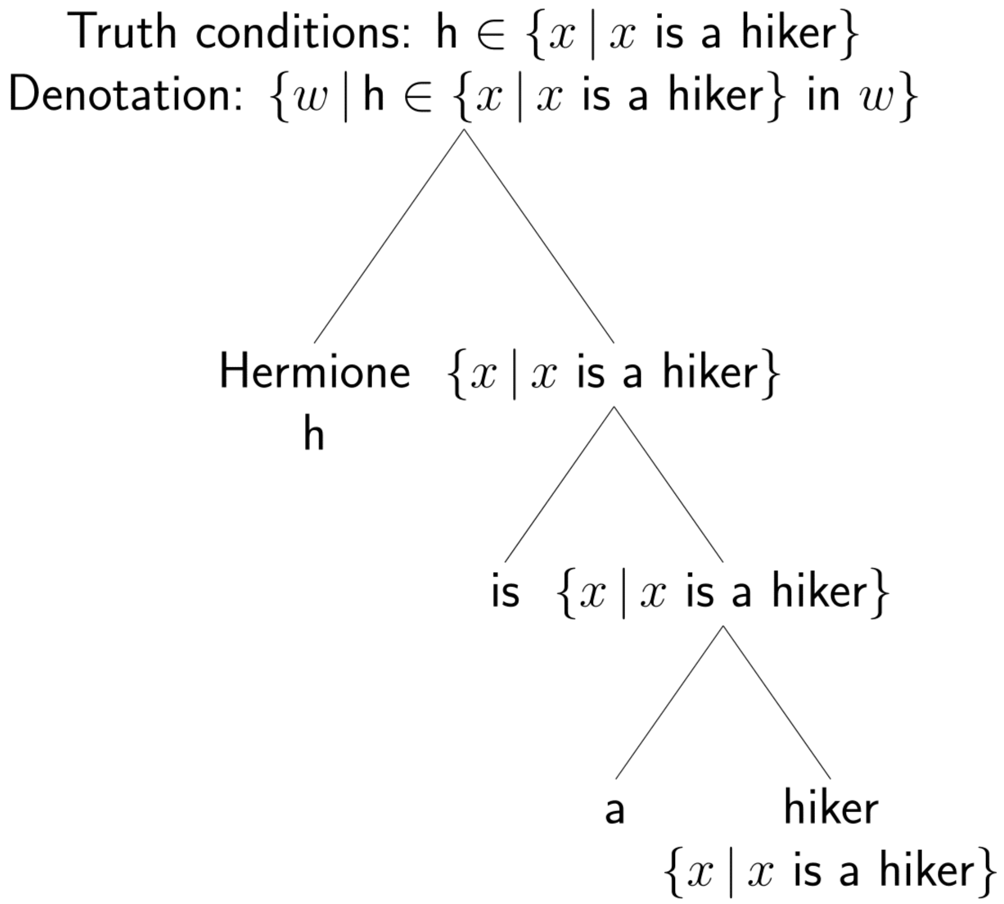


In-class practice III

- Write the truth conditions of (43) and (44) in set theoretical notation.
- Write the denotations of (43), (44), and (45) as propositions in set theoretical notation.
- Derive the truth conditions and the denotation of the sentence in (46) compositionally, following the same steps as we did for *Hermione is a hiker*.

(43) Harry hikes.

(44) Luna doesn't hike.

(45) Harry hikes and Luna doesn't hike.

(46) Snape is a professor.

Modification

We have learnt how to derive meanings of copula sentences with nominal and adjectival predicates:

(47) Hedwig is an owl.

(48) Hedwig is white.

But we can also have sentences in which an adjective modifies a noun:

(49) Hedwig is a white owl.

If *owl* and *white* both denote properties that expect individual arguments, how do they combine? One can't saturate the other! Nor do we want the resulting denotation of *white owl* to be a proposition—we want it to be a property that can be then saturated by *Hedwig*.

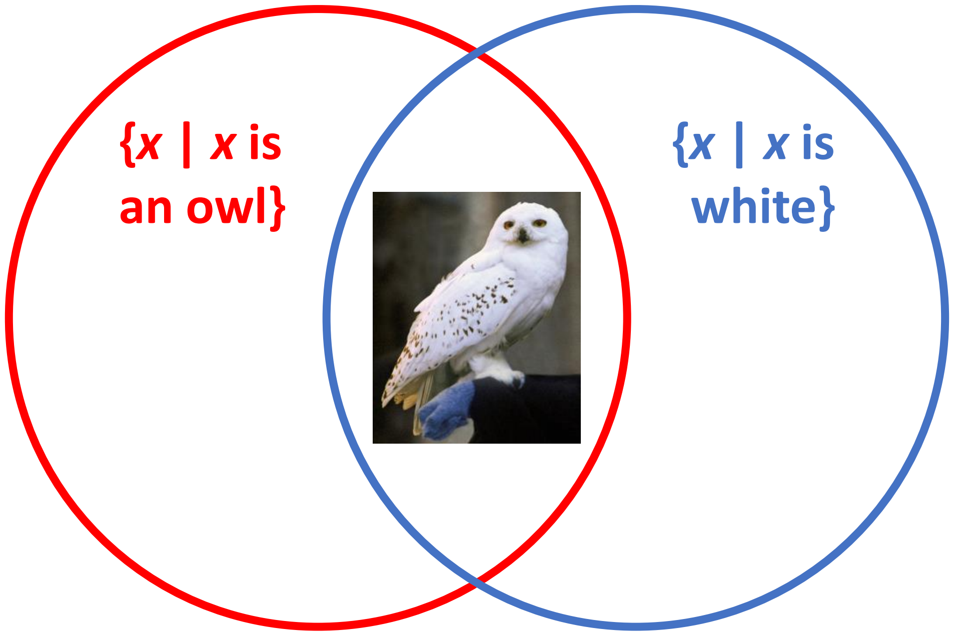
Modification

Note that *Hedwig is a white owl* entails both that Hedwig is an owl and that Hedwig is white.

In other words this sentence says that Hedwig is in the intersection of the set of owls and the set of white things.

Adjectives that behave like this are called **intersective**.

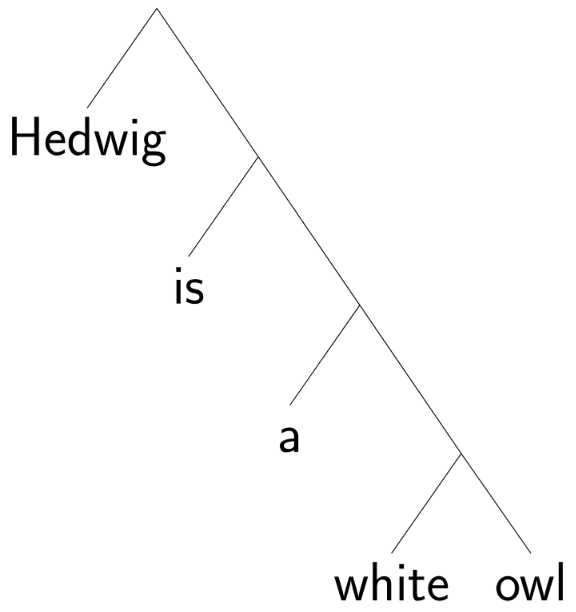
We can then introduce a new compositional mechanism to combine such adjectives with nouns, **predicate modification**, which combines two one-place predicates via set intersection.



Modification

Deriving *Hedwig is a white owl* compositionally:

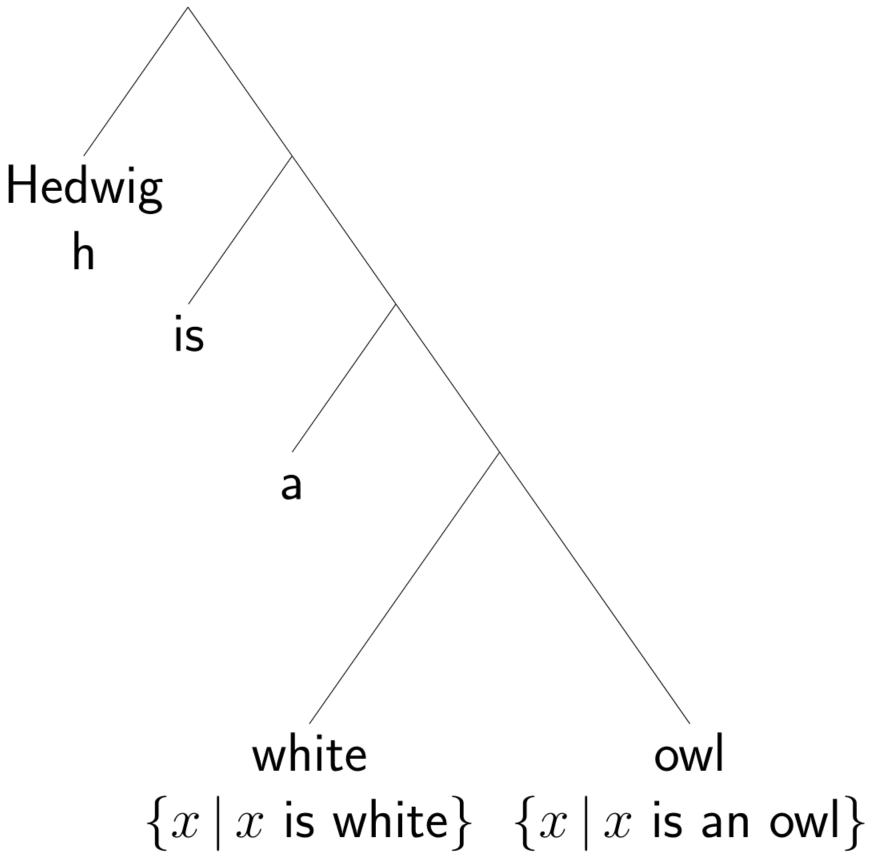
- Draw a simplified tree of the sentence.



Modification

Deriving *Hedwig is a white owl* compositionally:

- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.



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Deriving *Hedwig is a white owl* compositionally:

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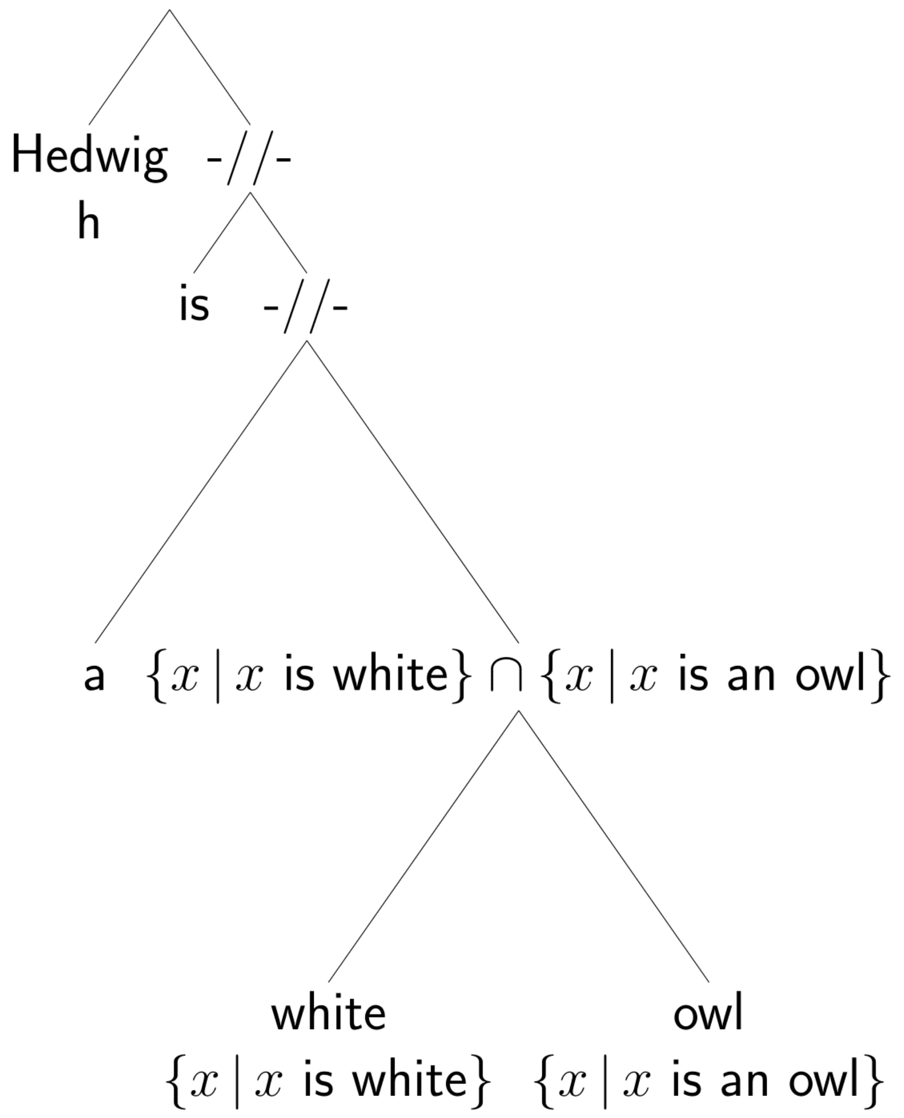
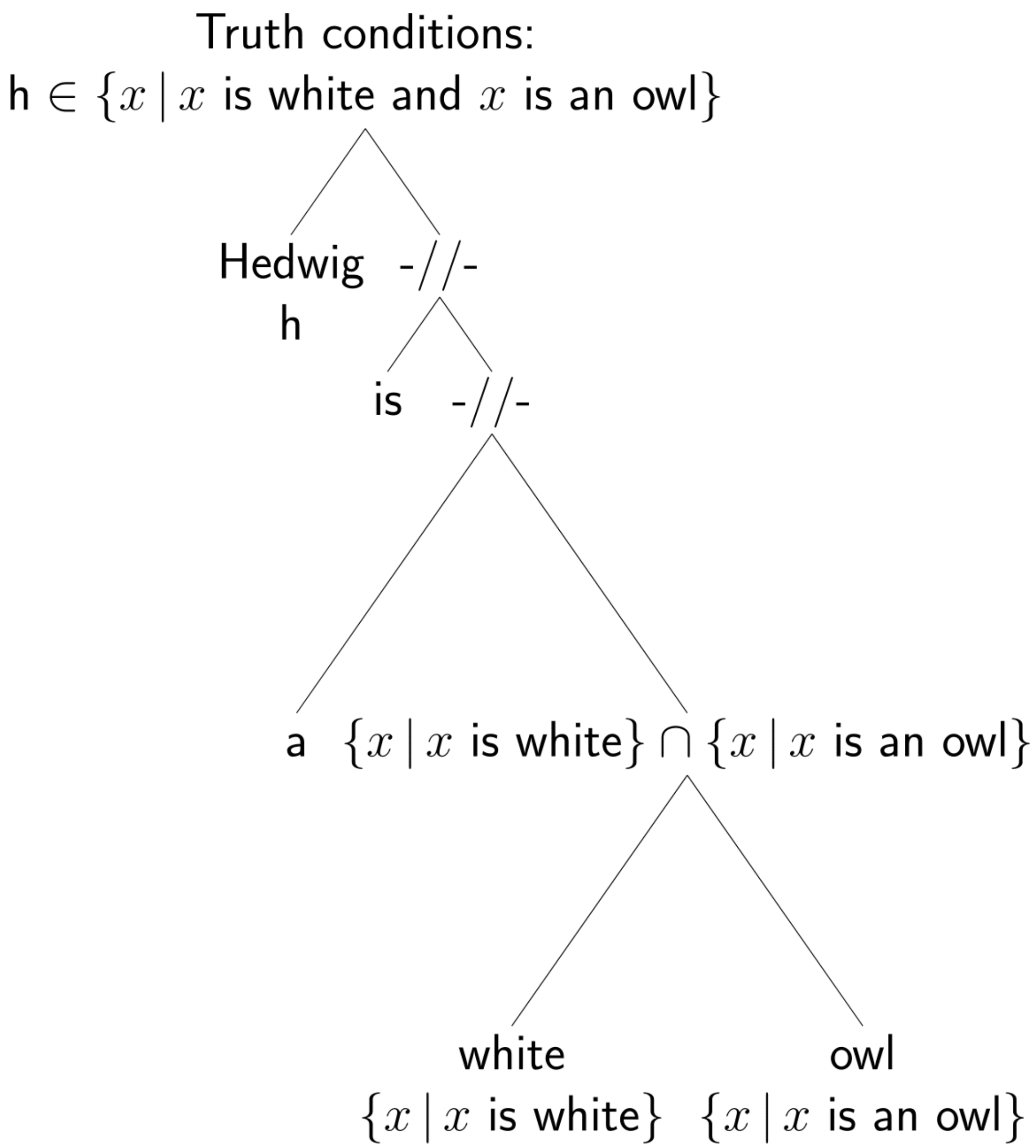
- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.
- Write denotations (extensions) of each non-terminal non-root node, treating *is* and *a* as vacuous.



Modification

Deriving *Hedwig is a white owl* compositionally:

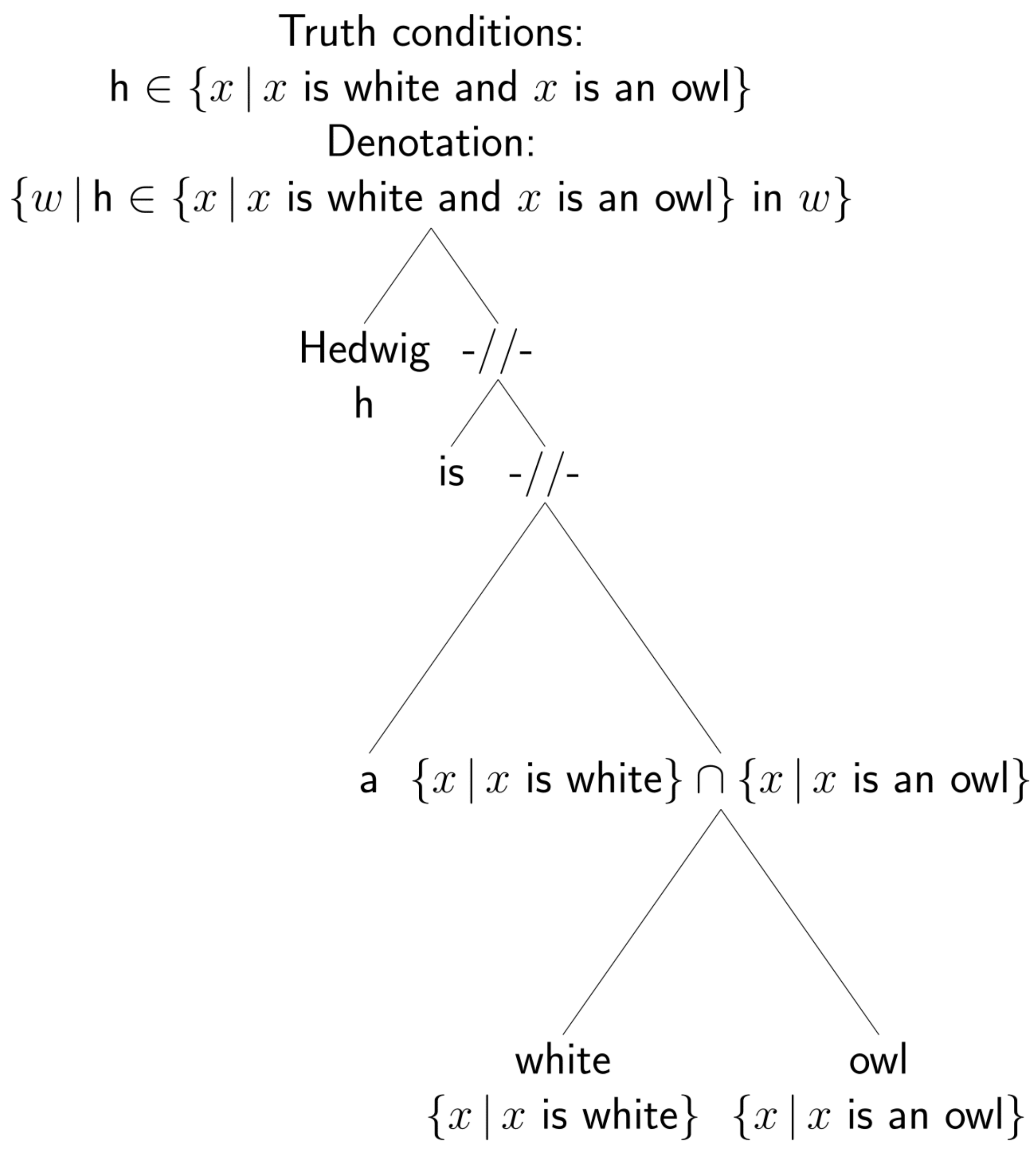
- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.
- Write denotations (extensions) of each non-terminal non-root node, treating *is* and *a* as vacuous.
- Write the truth conditions of the entire sentence in set theoretical notation. You may simplify things at this step (get rid of the intersection symbol).



Modification

Deriving *Hedwig is a white owl* compositionally:

- Draw a simplified tree of the sentence.
- Write denotations (extensions) of each terminal node except *is* and *a*, in predicate notation where relevant.
- Write denotations (extensions) of each non-terminal non-root node, treating *is* and *a* as vacuous.
- Write the truth conditions of the entire sentence in set theoretical notation. You may simplify things at this step (get rid of the intersection symbol).
- Write the denotation of the entire sentence as a proposition in set theoretical notation.



Modification

Not all adjectives are intersective, however. Consider (50) and (51) below. In (50) the conclusion is justified, but in (51) it's not.

(50) a. Snape is a male potioneer.

b. Snape is a cellist.

c. Therefore, Snape is a male cellist.

(51) a. Snape is a skillful potioneer.

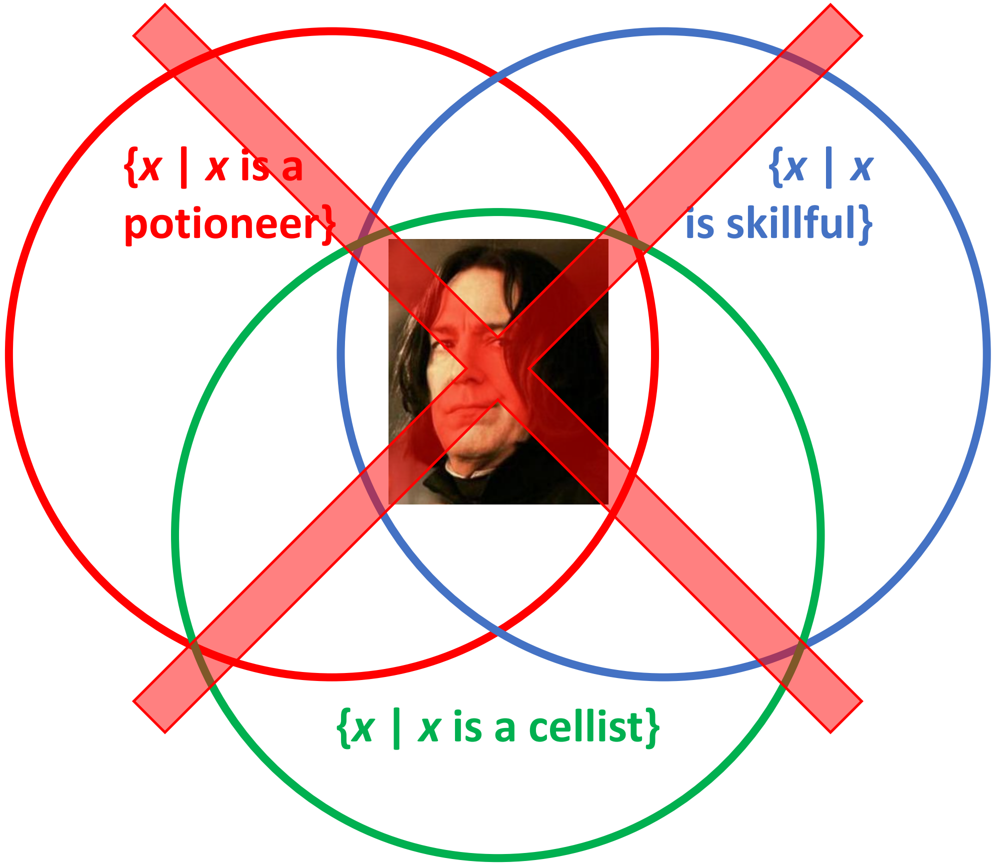
b. Snape is a cellist.

c. Therefore, Snape is a skillful cellist.

In (51) *skillful potioneer* doesn't denote the intersection of skillful entities and potioneers; rather it picks out a subset of potioneers. Adjectives that behave like this are called **subsective**.

Modification

Subsective adjectives can’t possibly denote sets of individuals.



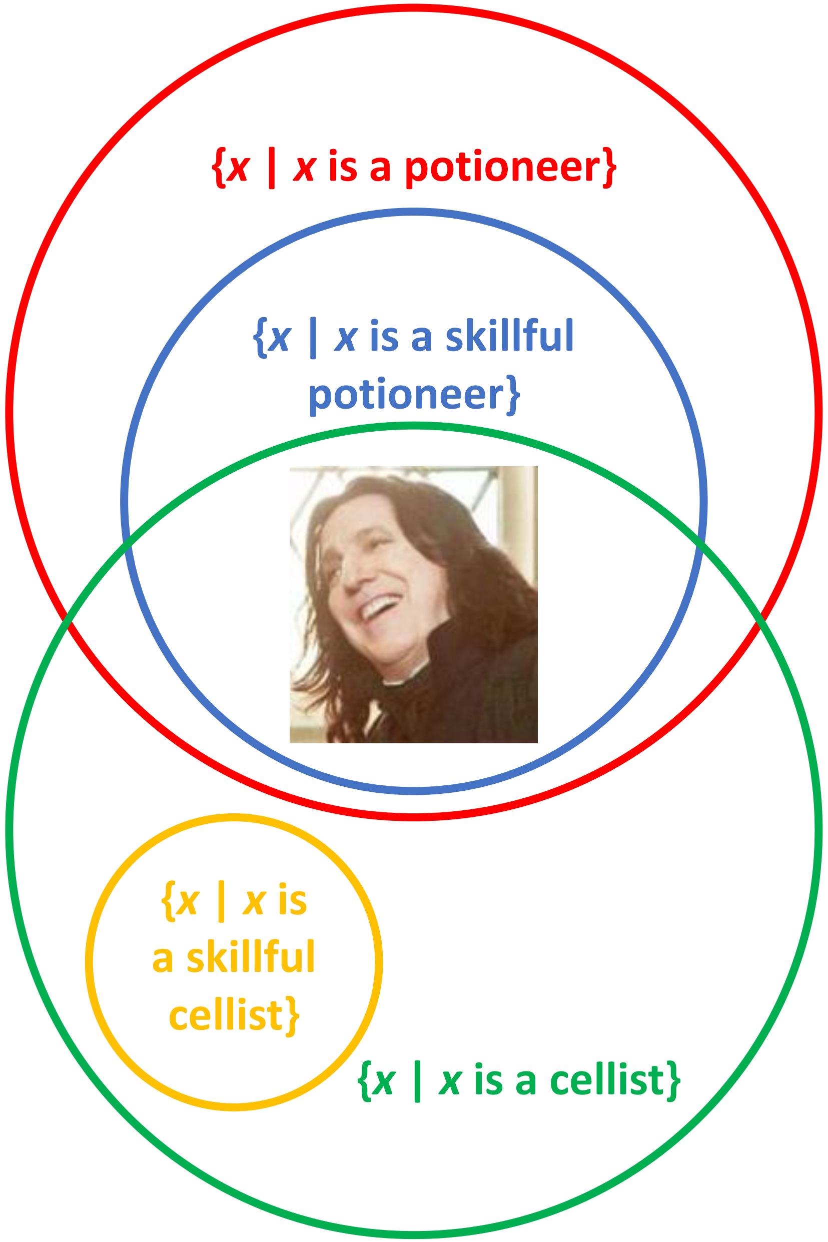
Modification

Subsective adjectives can't possibly denote sets of individuals.

Instead let's treat adjectives like *skillful* as higher-order properties, saturated by ordinary properties like *potioneer*. The result is a complex ordinary property.

This is **higher-order saturation**, but it is still the same compositional mechanism as ordinary saturation.

Thus, subsective adjectives like *skillful* are associations between sets of individuals like {*x* | *x* is a potioneer} and subsets of such sets like {*x* | *x* is a skillful potioneer}.



Modification

But once we’ve helped ourselves to higher-order saturation, we could use it for all adjectives, including the intersective ones. That way we don’t have to introduce a different compositional mechanism (predicate modification).

But what would we do with predicative uses of adjectives then, as in *Hermione is smart*?

Two options:

- Adjectives have two meanings (for predicative and attributive uses).
- Adjectives have only one meaning (the more complex one), but copula sentences with adjectives are not composed by simply saturating an adjectival predicate with an individual argument (e.g., we could give a non-trivial meaning to *is*).

Modification

There are other types of non-intersective adjectives that would also need to be treated as higher-order properties. From *Snape is a skillful potioneer* we can at least infer that Snape is a potioneer. But what about the following examples?

(52) Draco is an alleged Death Eater.

↛ Draco is a Death Eater.

↛ Draco is not a Death Eater.

(53) Snape is a former Headmaster.

↛ Snape is a Headmaster.

→ Snape is not a Headmaster.

(54) This is a fake wand.

?↛ This is a wand.

?→ This is not a wand.

Modification

Alleged N doesn't entail *N*, nor does it entail *not N* (the complement set of *N*). Adjectives that behave like this are called **plain non-subsective**.

Former N or *fake N* seem to entail *not N* (even though it's a controversial issue). Adjectives that behave like this are called **privative**.

Modification

Sometimes adjectives are **vague**. **Gradable adjectives** are often vague. For example, does (55) entail (56)?

(55) Griphook is a tall goblin.

(56) Griphook is tall.

Griphook might be tall for a goblin, but not necessarily if our comparison set includes all magical beings.

Thus, vague adjectives can’t denote sets of individuals that combine with nouns via predicate modification either, but have to be treated as higher-order properties.

In-class practice IV

- Derive the truth conditions and the denotation of the sentence in (57) compositionally, following the same steps as we did for *Hedwig is a white owl*.

(57) Crookshanks is a ginger cat.

- Come up with one intersective, one subsective, one plain non-subsective, and one privative adjective (different from those used in these slides). Use the inference test to demonstrate their nature (see examples (50)–(54) for reference).

What you need to know

What you need to know

Key notions:

- approaches to meaning: semantics; lexical semantics; compositional semantics; truth conditions vs. truth values; possible worlds; denotations; intensions vs. extensions
- types of linguistic expressions: declarative, interrogative, and imperative sentences; logical connectives (conjunction, disjunction, and negation); names; one-place verbal, nominal, and adjectival predicates; predicative and attributive adjectives
- types of adjectives: intersective; subsective; plain non-subsective; privative; vague
- types of denotations: propositions; referents/individuals/entities; ordinary and higher-order properties
- compositional mechanisms: ordinary and higher-order saturation; predicate modification
- types of semantic relationships between sentences: entailment; contradiction
- set-theoretical notions: sets; set members/elements; cardinality; infinite sets; singleton sets; the empty set; (proper) subsets; (proper) supersets; set intersection; set union; set difference; relative and absolute complements; disjoint sets
- other: exclusive vs. inclusive disjunction

What you need to know

Answers to the following questions:

- Why should we think of what declarative sentences mean in terms of their truth conditions?
- Why do we model meanings of declarative sentences as sets of possible worlds?
- What two options do we have for combining an adjective and a noun into a complex predicate? What are their pros and cons? Which one can handle all types of adjectives better?

What you need to know

Skills:

- Model conjunction, disjunction, and negation of declarative sentences via set operations; draw diagrams of complex sentences that contain these connectives.
- Compositionally derive truth conditions and propositional denotations of the following types of declarative sentences using set-theoretical notions and notation:
  - sentences consisting of a name and a one-place predicate (verbal, nominal, or adjectival), such as *Hermione hikes*, *Hermione is smart*, *Hedwig is an owl*;
  - sentences consisting of a name and a nominal predicate modified by adjectival predicates, such as *Hedwig is a white owl*.