Quantifiers

Readings: Portner, Ch. 6.1–2

1. Generalized quantifiers

1.1. What is a quantifier?

- Not all DPs refer:

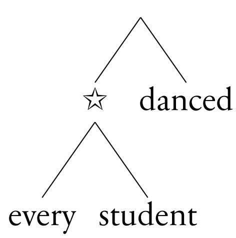
(1) a. Every student danced.
  b. No physicist is bearded.
  c. No one has ever seen a unicorn, because there aren't any.

- *Quantifiers* are non-referring DPs that indicate the quantity of something.
- Terminology:
  - *Quantifiers*: every man, no woman, three kings, most unicorns, more than five marbles, someone, everyone, nobody, etc.
  - *Determiners*: every, some, no, much, two, etc.

1.2. Compositional semantics of quantifiers

- The tree for (1a) is given below:

(2)



> **In-class Exercise 1**
>
> - Add the following to the tree in (2):
>   - The extensions of *student* and *danced* in set theory notation.
>   - The truth conditions of the whole sentence (i) in predicate logic, (ii) in set theory notation (hint: use subsethood).

1.2.1. How do quantifiers contribute to the meaning of sentences they occur in?

- What is the denotation of node ☆ in (2)?
- We know two compositional mechanisms: saturation and predicate modification.
- Only saturation would give us a proposition here. So, since we want a proposition, the mechanism in (2) must be saturation.
- Problem: *every student* can't be an argument of *danced*.

- Solution: let *danced* be the argument of *every student*.
- Details: we treat quantifiers as *properties of properties*. That is, the extension of a quantifier is a *set of sets*. We call quantifiers understood as sets of sets *generalized quantifiers*.
- For example:
  - *Every student* denotes the set of all properties every student has, or the set of all sets that every student is a member of.
  - When *every student* combines with *danced*, the result is true iff *danced* is in the set denoted by *every student*. In other words, if *danced* is a property that every student has.
  - Assuming a world w_8 with three students and their properties summarized in table (3), only the first two properties from the table will be in the denotation of *every student*.

(3)

	Hannah	Luna	Mary
smiled	✓	✓	✓
is smart	✓	✓	✓
dances	X	✓	✓
is blond	X	✓	X
likes lemon drops	X	X	X

In-class Exercise 2

- Look again at the table in (3) for world w_8. Write the denotations of the following quantifiers as sets of sets:

(4) a. $[\![\text{two students}]\!] =$

b. $[\![\text{no student}]\!] =$

c. $[\![\text{most students}]\!] =$

d. $[\![\text{some student}]\!] =$

1.2.2. Determiners as relations between sets

- Determiners take two sets and say something about the relationship between them.
- E.g., *every* first combines with a set A and then with a set B and says that A is a subset of B.
- What about other determiners?

In-class Exercise 3

- Write the denotations of the determiner after it has combined with arguments A and B:

(5) a. Example:
$[\![\text{two}]\!](A)(B) = 1$ iff $|A \cap B| = 2$

b. $[\![\text{no}]\!](A)(B) = 1$ iff

c. $[\![\text{some}]\!](A)(B) = 1$ iff

d. $[\![\text{most}]\!](A)(B) = 1$ iff

- Write the truth conditions of the following sentences as in (5) above:

(6) a. Two professors laughed.

b. Some physicists are bearded.

c. No turtle sleeps.

- Draw a tree for *No student dances*. Write the extension in w_8 of all nodes and write the truth conditions of the whole sentence.

2. All DPs as generalized quantifiers: DP coordination

- DPs can be coordinated:

(7) a. Benjamin and Hannah smiled.
b. Benjamin and two students like Felix.
c. Benjamin or some cats entered the room.

- Question: why is this a problem for our treatment of conjunction as set intersection and disjunction as set union?

- Here's a solution for this problem: we can treat all DPs as generalized quantifiers.
- Generalized quantifiers are sets. And if we represent all of DPs as sets, then we can keep our old treatment of conjunction as set intersection and of disjunction as set union.
- For example, a name like *Benjamin* would denote the set of all Benjamin's properties, i.e., the set of all sets that Benjamin is a member of.

In-class Exercise 3

- Below is an updated table from (3), to which Benjamin's properties in w_8 were added.
- Write the denotations of the following expressions as sets of sets in w_8:

	Hannah	Luna	Mary	Benjamin
smiled	✓	✓	✓	X
is smart	✓	✓	✓	✓
dances	X	✓	✓	✓
is blond	X	✓	X	X
likes lemon drops	X	X	X	✓

(8) a. $[\![$Benjamin$]\!] =$

b. $[\![$Benjamin and every student$]\!] =$

c. $[\![$Benjamin or Hannah$]\!] =$

d. $[\![$Benjamin or some student$]\!] =$

3. Fictional determiners

- Recall: determiners denote two-place relations between sets.
- There are A LOT of possible two-place relations between sets, and not all of them are realized as determiners in natural language. For example, there is no determiner *equi*:

(9) $[\![\text{equi}]\!](A)(B) = 1$ iff $|A| = |B|$

- So, (10) would be true iff $|\{x \mid x \text{ is an apple}\}| = |\{x \mid x \text{ is red}\}|$ (the number of apples is the same as the number of red things).

(10) Equi apples are red.

- Cross-linguistic generalization: languages don't have determiners with the meaning of *equi*. The same goes for many other determiners that would in principle be possible, but for some reason don't get realized in natural lanugage. What is that reason?
- One approach: all those determiners that do get realized share certain properties. For example, They are all *conservative*:

(11) A determiner R is conservative iff it holds that:

$$R(A)(B) \quad \text{iff} \quad R(A)(A \cap B)$$

- Intuitively: we don't need to look at all elements in B, but it suffices to look at those in $A \cap B$.
- For example, *every* is conservative:

(12) $[\![\text{every}]\!](A)(B)$ iff $[\![\text{every}]\!](A)(A \cap B))$.

- To see this, let's say that A is the set of apples and B is the set of red things. It's easy to see that (13) holds true.

(13) *Every apple is <u>red</u>* iff *Every apple is a <u>red apple</u>*

In-class Exercise 4

Show that *equi* is not conservative by constructing a counterexample.

- How does the observation that all natural language determiners are conservative help with explaining the cross-linguistic generalization?

- One idea: conservative determiners are easier to acquire.
- Hunter and Lidz (2013) experimentally tested children's ability to learn novel conservative and non-conservative determiners, based on equivalent input. They found evidence that 4- and 5-year-olds fail to learn the non-conservative determiner, while they succeed in learning the comparable conservative determiner.

4. Monotonicity properties

- Sentences with quantifiers allow different inference patterns, depending on the determiner that is used.
- For example:

(14) **Some** student dances and is happy. $[\![\text{some}]\!](S)(D \cap H)$
$\rightarrow$ **Some** student dances. $[\![\text{some}]\!](S)(D)$

(15) **No** student dances and is happy. $[\![\text{no}]\!](S)(D \cap H)$
$\not\rightarrow$ **No** student dances. $[\![\text{no}]\!](S)(D)$

- The above inference "moves" from a subset $(D \cap H)$ to a superset (D).
- Determiners like *some* that allow this inferenece are called *upward-monotone*.
- More specifically, *some* is upward-monotone *in its right argument*. To express this, we also write MON↑.
- In total, there are four kinds of monotonicity:
  - ↑MON: upward-monotonicity in the left argument
  - ↓MON: downward-monotonicity in the left argument
  - MON↑: upward-monotonicity in the right argument
  - MON↓: downward-monotonicity in the right argument

In-class Exercise 4

- You already know from examples above that *some* is MON↑ and that *no* is not MON↑. Test whether these determiners exhibit the three other kinds of monotonicity.

What you need to know

Key notions: quantifiers, determiners, generalized quantifiers, conservativity, upward-monotonicity (in the left/right argument), downward-monotonicity (in the left/right argument),

Answers to the following questions:

- What do generalized quantifiers denote?
- Why does treating all DPs as generalized quantifiers solve the problem of generalized coordination?
- How might we explain that only some of all those quantifiers that are in principle possible get realized in natural language?

Skills:

- Give generalized quantifier denotations in set theoretical notation (using subsethood, intersection, cardinality, etc.) to DPs with determiners (e.g., *every student*, *some student*, *two students*, *no student*), names (e.g., *Benjamin*), and coordinated DPs (e.g., *Benjamin and every student*, *two physicists or some student*).
- Represent truth conditions of sentences with generalized quantifiers in set theoretical notation.
- Test the monotonicity properties of a determiner.