## LESSON 2: Constants (1.1) / Predicate Symbols (1.2) / Atomic Sentences (1.3) / General first-order languages (1.4)

Remind of quiz next class covering material from today (lesson 02) and lesson 01 …

**Reading pp. 19-25:** Atomic sentences

### POWERPOINT SLIDE #1

'Atomic' sentences in FOL are like the most basic sentences of English that have **one subject and one predicate**, and may or may not have objects which together with the verb would make up the predicate. Examples:

Max ran.
Max saw Claire.
Claire gave Scruffy to Max.

### POWERPOINT SLIDE #2

So, the last sentence above would be analyzed in English grammar as having a **subject** ('Claire'), a **verb** ('gave'), a **direct object** ('Scruffy'), and an **indirect object** ('(to) Max'). The last three components would together make up the **predicate**.

### POWERPOINT SLIDE #3

In FOL, things are different. If were were going to translate the previous simple sentences of English into atomic sentences of FOL, we might write them like this:

| | | |
|---|---|---|
| **Ran(Max)** | = | "Max ran." |
| **Saw(Max, Claire)** | = | "Max saw Claire" |
| **Gave(Claire, Scruffy, Max)** | = | "Claire gave Scruffy to Max" |

We can also write sentences in FOL specific to the blocks world of Tarski's World:

| | | |
|---|---|---|
| **Cube(a)** | = | "(Object) *a* is a cube" |
| **LeftOf(a,b)** | = | "(Object) *a* is left of (object) *b*" |
| **Between(a,b,c)** | = | "(Object) *a* is between (objects) *b* and *c*" |

### POWERPOINT SLIDE #4

Notice that what was the *verb* in English appears first (i.e., in the front) in sentences of FOL, and the *subject* and any *objects* appear listed in parentheses immediately following the verb.

Instead of saying 'verb' in FOL, we call this simply the ***predicate***. And what we call 'subject', 'direct object', and 'indirect object' in English are all in FOL simply called ***logical subjects*** of the predicate, or more commonly the ***arguments*** of the predicate (notice this is a different meaning of the word

'argument' than the meaning we used last lesson when talking about good or bad 'arguments' like the one about Socrates).

Notice that 'Claire', 'Scruffy', 'Max', or in the blocks world letters like 'a', 'b', and 'c', are really just *names* for individuals or objects in some world. That is, each name *refers to* some person or object in the world. In logic, when we want to talk about the way that the arguments of a verb have reference to objects in some world, the more common way to talk about these 'name' words is as ***'individual constants'*** (where an individual constant **names** one and only one **individual** object, always the same object—so the name's reference is '**constant**' and does not vary). In the language used with Tarski's World, the individual constants are simply **letters** that name different kinds of blocks on the chessboard, but an FOL can also contain individual constants with more typical names (like "Max" or "Scruffy").

POWERPOINT SLIDE #5

So, in atomic sentences of FOL, we find both **predicates** and **individual constants**, the latter serving as the **arguments** or **logical subjects** of the former. Predicates describe *properties* of their arguments; these properties in the blocks world we'll be dealing a lot with in this course include various relations (of size or location) between different blocks. Again though, don't forget that an FOL can contain more "normal" predicates as well, like 'Give' or 'Own'.

***A predicate* plus one or more *individual constants* gives you an *atomic sentence*.**

POWERPOINT SLIDE #6

A predicate that combines with just *one* logical subject (i.e., takes one argument) has an *arity* of 1 (it's a ***unary*** predicate).

A predicate that combines with *two* logical subjects (i.e., takes two arguments) has an arity of 2 (it's a ***binary*** predicate).

A predicate that combines with *three* logical subjects (i.e., takes three arguments) has an arity of 3 (it's a ***ternary*** predicate).

POWERPOINT SLIDE #7

**Table 1.1 on p. 22** of the text gives you a list of predicates and individual constants of the 'blocks world' language we will be using so much in this course. Notice that each predicate is given a precise definition that may not correspond exactly with English.

*How does the definition of 'Between', for example, differ from how we might use the word in English???* (In the blocks-world language, 'between' only holds when the three objects involved are *all in a straight line* .... either all in the same row, column, or diagonal. English 'between' isn't so strict about this.)

*Note also an important peculiarity of Tarski's World: Large objects cannot adjoin other objects . . .*

Also, the *order of arguments* of a predicate matters!
E.g., **LeftOf(b,c)** versus **LeftOf(c,b)** … these atomic sentences have different meanings.

## POWERPOINT SLIDES #8-9

Table 1.1 …

## POWERPOINT SLIDE #10

Each atomic sentence of FOL expresses a claim that has a *truth-value* of either True (T) or False (F).

To know whether a sentence is T or F, you typically have to look at a world and determine whether the sentence is T or F *in that world*. For example, the FOL sentence **Cube(b)** (“*b is a cube*”) may be T in some worlds but F in others.

## POWERPOINT SLIDE #11

- Launch Tarski's World
- Complete **exercise 1.4 on p. 26**, including building the world
- Complete **exercise 1.7 on p. 27** (answers are below)

## POWERPOINT SLIDE #12

**1.7** (answers)

| | Orig | 90 | 180 | 270 |
|---|---|---|---|---|
| 1 | F | F | F | F |
| 2 | F | F | F | F |
| 3 | T | F | F | T |
| 4 | F | F | T | T |
| 5 | T | F | F | F |
| 6 | F | F | T | F |

## POWERPOINT SLIDE #13

The main point of **section 1.4** in the textbook is that *FOLs will differ* in their choices of *individual constants* and *predicates* (though there are other elements of FOLs—namely, their connectives and quantifiers, which we will learn about soon—that are common to all FOLs).

The names and predicates you choose (if you're designing an FOL) all depend on the objects in the world or domain that your language describes, and the properties of the objects and the relations between those objects. (Obviously, an FOL is going to be much more restricted and narrow than a natural language like English. An FOL is a formal, **specialized** language.)

The books gives the example of two different predicates, **GaveScruffy** versus **Gave**. Does everyone see how the following two atomic sentences would say the same thing, defined in the way the book does?