LOST
I'VE LOST MY ENGLISH-JAPANESE DICTIONARY. NOW FINDING IT HARD TO BUY CHEAP WHISKEY IN TOKYO. IF YOU FIND IT MAIL! ME@THEARTOFASBESTOS.COM

Class 2: Language

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cs1120 Fall 2009

Menu

- First Main Theme: Recursive Definitions
- Survey Results
- Language

What's the longest word in the English language?

Longest Words?

honorificabilitudinitatibus (27 letters, longest by Shakespeare)
With honor.

antidisestablishmentarianism (28 letters)
Movement against division of church and state.

hippopotomonstrosesquipedaliophobia (35 letters)
Fear of long words.

pneumonoultramicroscopicsilicovolcanoconiosis (45 letters)
(longest word in most dictionaries)
Lung disease contracted from volcanic particles.

Like all words, these words are "made up".

Making Longer Words

antihippopotomonstrosesquipedaliophobia
Against the fear of long words.

antiantihippopotomonstrosesquipedaliophobia
Against a thing against the fear of long words.

Language is *Recursive*

No matter what word you think is the longest word, I can always make up a longer one!

word ::= **anti-***word*

By itself, this definition of *word* is circular.

Zero, One, Infinity

word ::= **anti-***word*   This rule can make 0 words.

word ::= **hippopotomonstrosesquipedaliophobia**
This rule can make 1 word.

word ::= **anti-***word*
word ::= **hippopotomonstrosesquipedaliophobia**
These two rules can make **infinitely** many words, enough to express all ideas in the universe!

Recursive Definitions

- We can define things in terms of themselves
- Recursive definitions are not circular:
  they eventually end with something real

word ::= **anti-***word*
word ::= **hippopotomonstrosesquipedaliophobia**

Recursive Definitions

Allow us to express infinitely many things starting with a few.

This is powerful!

We will see **lots** of examples in this course.

Menu

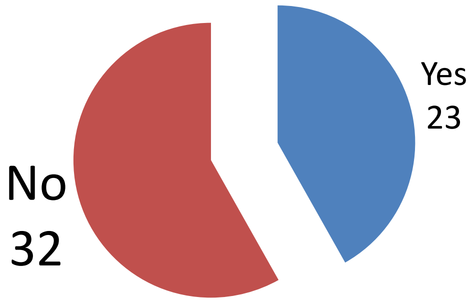
- First Main Theme: Recursive Definitions
- **Survey Results**
- Language

Who is in the class?

Sarah
Josh
Katie
Stephen
Erika
Omer
Trig
Richard
Stephanie
Ian
Annie
Travis
Emily
Lizzie
Kevin
John
Lauren
Allison
Ginny
Taylor
Justin
Jordan
Maylon
Jihee
John Marion
Rachel
Christine
Morgan
Steven
Julie
Melissa
John Kim
Muzzammil
Qihan
Daniel
Andrino
Devon
Siddharth
Agnes
Pyrchla
Lucy
Bill-L
Daphna
Giorgio
Brittney
Brian
Kiran
Mark
Rose
Tom
Anna
Joe
Scott
Casey
Jenny

Produced by http://www.wordle.net/

Ever written a computer program?



More survey results (and my answers to questions) will be posted on the website before Monday.

Language

What is a language?

Webster:

A ~~systematic~~ means of communicating ~~ideas or feelings~~ by the use of ~~conventionalized~~ signs, sounds, gestures, or marks having ~~understood~~ meanings.

Linguist’s Definition

(Charles Yang)

A description of pairs (*S*, *M*), where *S* stands for sound, or any kind of **surface forms**, and *M* stands for **meaning**.

A theory of language must specify the properties of *S* and *M*, and how they are related.

Languages

A **language** is:
- a **set of surface forms** (usually strings of characters), and
- a way to map any surface form in the language to a **meaning**

Caveat: computer scientists often use *language* to mean just a set of surface forms.

What are languages made of?

- **Primitives** (all languages have these)
  - The simplest surface forms with **meaning**
- **Means of Combination** (**all** languages have these)
  - Ways to make new surface forms from ones you already have
- **Means of Abstraction** (all **powerful** languages have these)
  - Ways to use simple surface forms to represent complicated ones

Does English have these?

- Primitives
  - ~~Words (?)~~

    ~~“**hippopotomonstrosesquipedaliophobia**” is **not** a primitive~~
  - Morphemes – smallest units of meaning

    e.g., **anti-** (“opposite”)
- Means of combination
  - e.g., *Sentence* ::= *Subject Verb Object*
  - Precise rules, but not the ones you learned in grammar school

Ending a sentence with a preposition is something up with which we will not put.
Winston Churchill

Does English have these?

- Means of abstraction
  - Pronouns: she, he, it, they, which, etc.
  - Confusing since they don't always mean the same thing, it depends on where they are used.

  The "**these"** in the slide title is an abstraction for the three elements of language introduced 2 slides ago.

  The "**they"** in the confusing sentence is an abstraction for pronouns.

How should we describe *precise* languages?

Requirements

- Describe **infinitely** many surface forms with a short description
  - Listing them all doesn't work: need ways to **generate** the surface forms

Today: formally

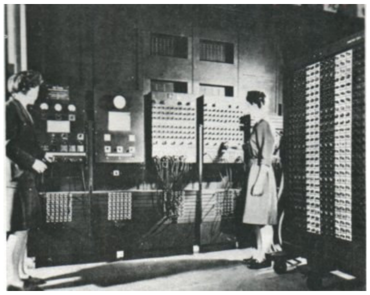
- Way to map each surface form to exactly one **precise meaning**

Monday: informally (using English)
Later: more formally (defining an interpreter)

ENIAC: Electronic Numerical Integrator and Computer

- Early WWII computer

  but **not** the first (PS4)
- Built to calculate bombing tables



Memory size:

twenty 10 decimal digit accumulators = 664 bits

ENIAC (1946): ½ mm

Apollo Guidance Computer (1969): 1 inch

You: 4.4 miles

Directions for Getting **6**

1. Choose any regular accumulator (ie. Accumulator #9).
2. Direct the Initiating Pulse to terminal *5i*.
3. The initiating pulse is produced by the initiating unit's *Io* terminal each time the Eniac is started. This terminal is usually, by default, plugged into Program Line 1-1 (described later). Simply connect a program cable from Program Line 1-1 to terminal *5i* on this Accumulator.
4. Set the Repeat Switch for Program Control 5 to 6.
5. Set the Operation Switch for Program Control 5 to ADD.
6. Set the Clear-Correct switch to C.
7. Turn on and clear the Eniac.
8. Normally, when the Eniac is first started, a clearing process is begun. If the Eniac had been previously started, or if there are random neons illuminated in the accumulators, the "Initial Clear" button of the Initiating device can be pressed.
9. Press the "Initiating Pulse Switch" that is located on the Initiating device.
10. **Stand back.**

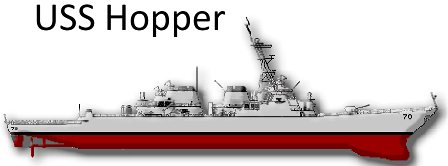
Admiral Grace Hopper

(1906-1992)

"Nobody believed that I had a running compiler and nobody would touch it. They told me computers could only do arithmetic."

- Mathematics PhD Yale, 1934
- Entered Navy, 1943
- First to program Mark I (first "large" computer, 51 feet long)
- Wrote first compiler (1952) – program for programming computers
- Co-designer of COBOL (most widely used programming language until a few years ago)

USS Hopper



"Dare and Do"

Guest on David Letterman

Nanostick

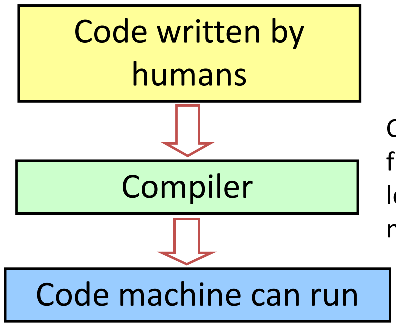
How far does light travel in 1 nanosecond?

```
> (define nanosecond (/ 1 (* 1000 1000 1000))) ;; 1 billionth of a s
> (define lightspeed 299792458) ; m / s
> (* lightspeed nanosecond)
149896229/500000000
> (exact->inexact (* lightspeed nanosecond))
0.299792458
```

= just under 1 foot

Lab machines have at least "2 GHz Pentium 4 CPU"

GHz = GigaHertz = 1 Billion times per second
They must finish a step before light travels **11.5 cm**!



Code written by humans

Compiler

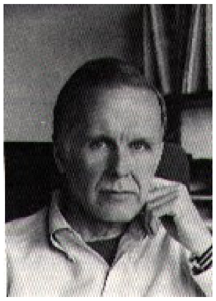
Code machine can run

Compiler translates from code in a high-level language to machine code

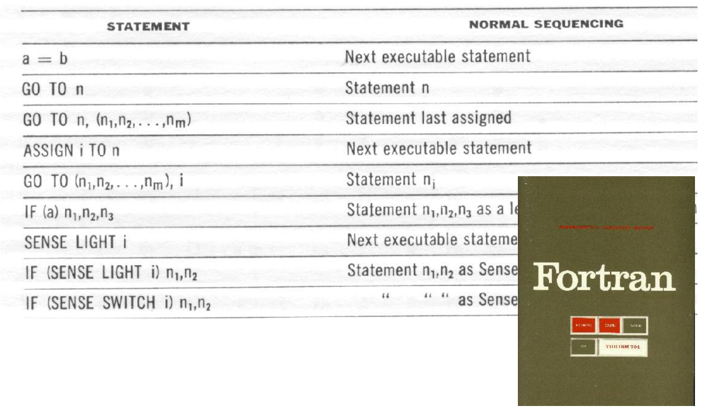
DrScheme uses an *interpreter*. An interpreter is like a compiler, except it runs quickly and quietly on small bits of code at a time.

John Backus

- Chemistry major at UVA (entered 1943)
- Flunked out after second semester
- Joined IBM as programmer in 1950
- Developed Fortran, first commercially successful programming language and compiler



IBM 704 Fortran manual, 1956



STATEMENT	NORMAL SEQUENCING
a = b	Next executable statement
GO TO n	Statement n
GO TO n, $(n_1,n_2,\ldots,n_m)$	Statement last assigned
ASSIGN i TO n	Next executable statement
GO TO $(n_1,n_2,\ldots,n_m)$, i	Statement n_i
IF (a) n_1,n_2,n_3	Statement n_1,n_2,n_3 as a le
SENSE LIGHT i	Next executable stateme
IF (SENSE LIGHT i) n_1,n_2	Statement n_1,n_2 as Sense
IF (SENSE SWITCH i) n_1,n_2	" " " as Sense

Fortran
THE IBM 704

Describing Languages

- Fortran language was described using English
  - Imprecise
  - Verbose, lots to read
  - Ad hoc

```
DO 10 I=1.10
```

Assigns `1.10` to the variable `DO10I`

```
DO 10 I=1,10
```

Loops for `I = 1` to `10`

(Often incorrectly blamed for loss of Mariner-I)

- Wanted a more precise way of describing a language

Backus Naur Form

symbol ::= *replacement*

We can replace *symbol* with *replacement*

A ::= *B* means anywhere you have an *A*, you can replace it with a *B*.

nonterminal – symbol that appears on left side of rule

terminals – symbol that **never** appears on the left side of a rule

BNF Example

Sentence ::= *NP Verb*

NP ::= *Noun*

Noun ::= **Dave**

Noun ::= **Scheme**

Verb ::= **rocks**

Verb ::= **sucks**

What are the *terminals*?

Dave, **Scheme**, **rocks**, **sucks**

How many different things can we express with this language?

4, but only 2 are true.

BNF Example

Sentence ::= *NP Verb*

NP ::= *Noun*

NP ::= *Noun* **and** *NP*

Noun ::= **Dave**

Noun ::= **Scheme**

Verb ::= **rocks**

Verb ::= **sucks**

How many different things can we express with this language?

Infinitely many!
Recursion is powerful.

Most Essential Scheme

Expr ::= *PrimitiveExpr*
PrimitiveExpr ::= ***Number***
PrimitiveExpr ::= **+** | ***** | **<=** | ...
Expr ::= ***Name***
Expr ::= *ApplicationExpr*
ApplicationExpr ::= **(***Expr MoreExprs***)**
MoreExprs ::=
MoreExprs ::= *Expr MoreExprs*

This is enough for everything you need for PS1

Charge

- **Problem Set 1**: due Wednesday
- Read through Chapter 3 by Monday
- Help Hours: posted on website

Sunday in Olsson 001 (6-8:30pm)

Monday in Thorton Stacks (noon-1:30pm); Small Hall (4-6:30pm)

Tuesday in Small Hall (2-3pm; 3:30-5pm; 7-8:30pm)