61A Lecture 28

Friday, November 4

The Logo Programming Language

A teaching language: designed for introductory programming

One syntactic form for all purposes: invoking a procedure

Only two data types: words and sentences

Code is data: a line of code is a sentence

An elegant tagline: no threshold, no ceiling

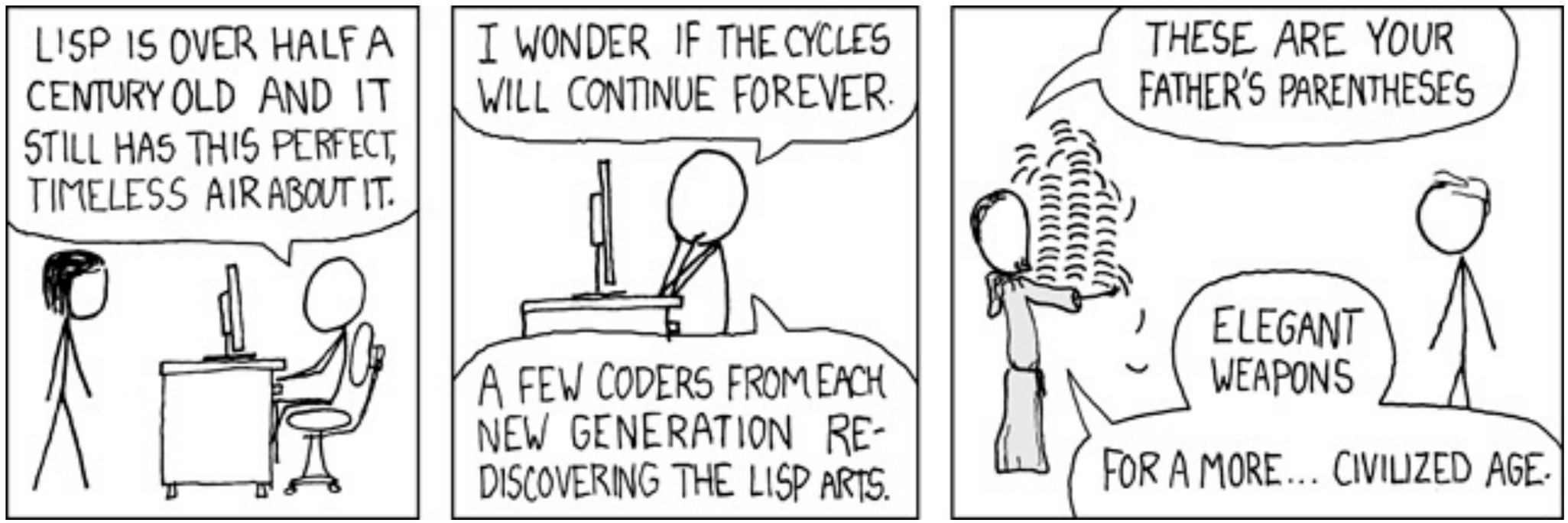
A bit of fun: turtle graphics

Demo

Logo is a Dialect of Lisp

What are people saying about Lisp?

- "The greatest single programming language ever designed."
  -Alan Kay (from the UI video), co-inventor of Smalltalk
- "The only computer language that is beautiful."
  -Neal Stephenson, John's favorite sci-fi author
- "God's programming language."
  -Brian Harvey, Father of CS 61A



http://imgs.xkcd.com/comics/lisp_cycles.png

Logo Fundamentals

Call expressions are delimited by spaces

Logo *procedures* are equivalent to Python functions

- A procedure takes *inputs* (arguments) that are values
- A procedure returns an *output* (return value)
- A procedure may output None to indicate no return value

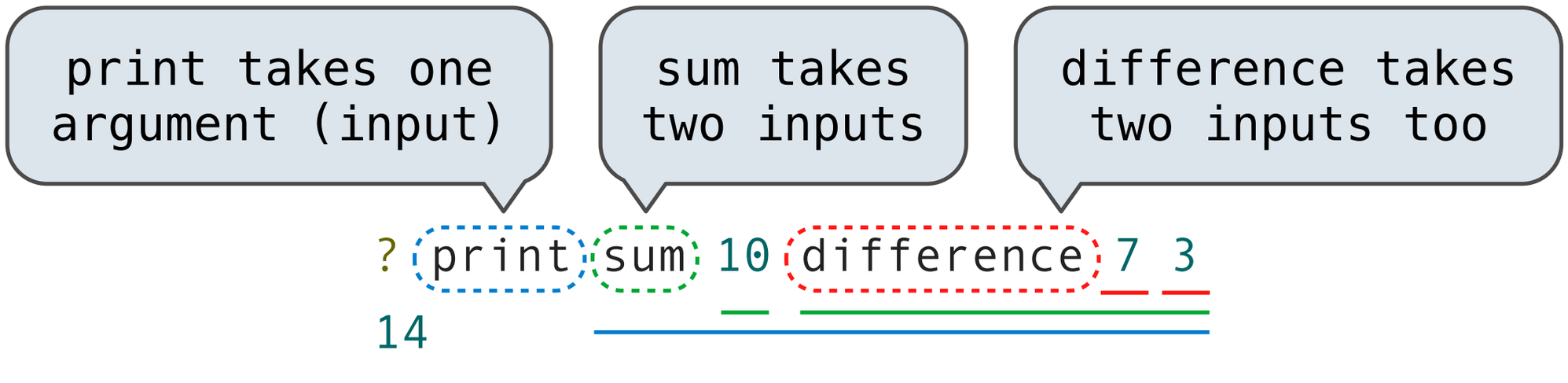
```
? print 5
5
```

Multiple expressions can appear in a single line

```
? print 1 print 2
1
2
```

Nested Call Expressions

The syntactic structure of expressions is determined by the number of arguments required by named procedures



One nested call expression

versus

Two expressions on one line

```
? print 1 print 2
1
2
```

Demo

Data Types and Quotation

Words are strings without spaces, representing text, numbers, and boolean values

```
? print "hello
hello
? print "sum
sum
? print "2
2
```

Sentences are immutable sequences of words and sentences

```
? print [hello world]
hello world
? show [hello world]
[hello world]
```

Sentence (List) Processing in Logo

Sentences can be constructed from words or sentences

Procedure	**Effect**
sentence	Output a sentence containing all elements of two sentences. Input words are converted to sentences.
list	Output a sentence containing the two inputs.
fput	Output a sentence containing the first input and all elements in the second input.

Demo

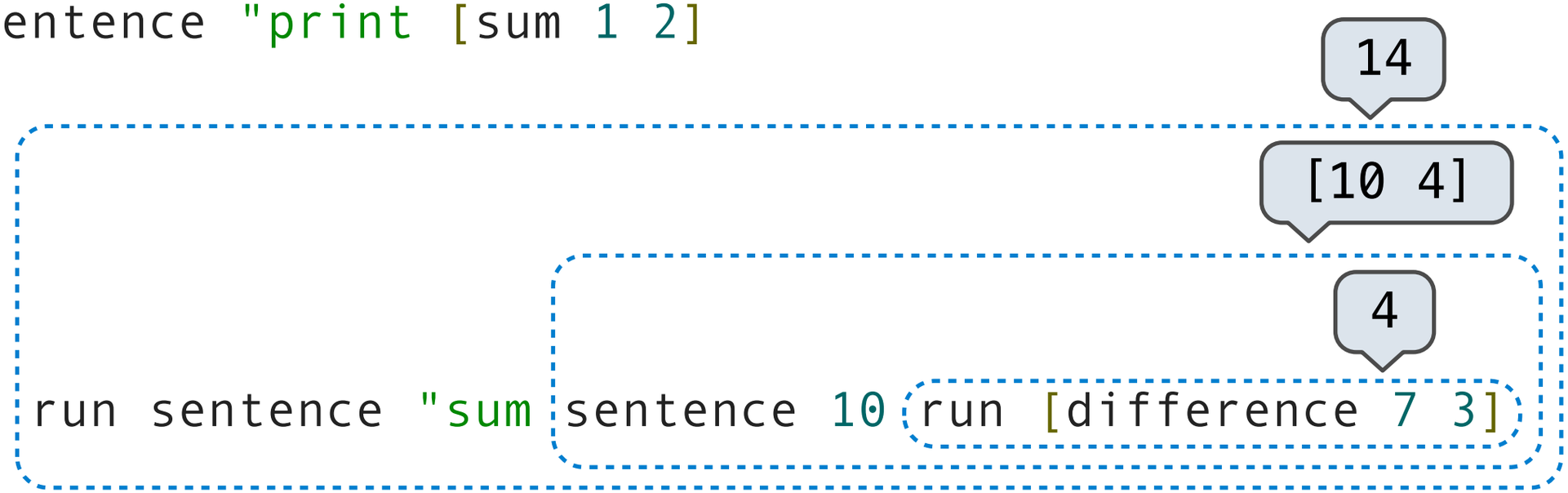
Expressions are Sentences

The run procedure evaluates a sentence as a line of Logo code and outputs its value

```
? run [print sum 1 2]
3
```

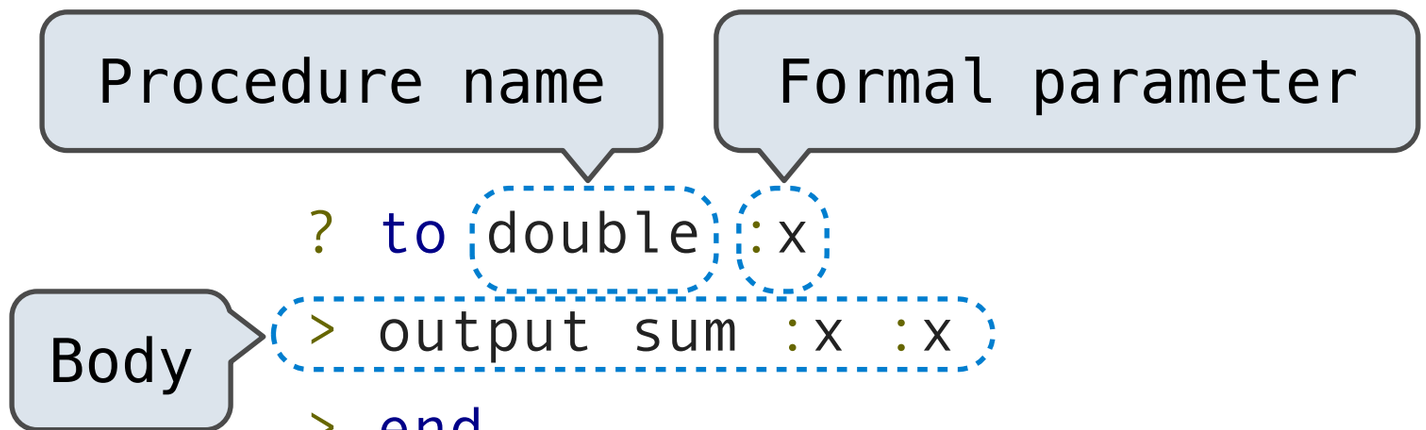
Its argument can be constructed from other procedure calls

```
? run sentence "print [sum 1 2]
3
? print run sentence "sum sentence 10 run [difference 7 3]
14
```



Procedures

Procedure definition is a special form, not a call expression




```
? print double 4
8
```

Procedures are not first-class objects in Logo; they can only ever be referenced by their original procedure name

Procedure names can be inputs or outputs

Conditional Procedures

If and ifelse are regular procedures in Logo

Meaning: They do not have a special evaluation procedure

They take sentences as inputs and run them conditionally

```
? to reciprocal :x
> if not :x = 0 [output 1 / :x]
> output "infinity
> end

? print reciprocal 2
0.5

? print reciprocal 0
infinity
```

Dynamic Scope

When one function calls another, the names bound in the local frame for the first are accessible to the body of the second

No isolation of formal parameters to function bodies, as we saw with lexical scope

```
? to print_x :x
> print_last_x
> end

? to print_last_x
> print :x
> end

? print_x 5
5
```

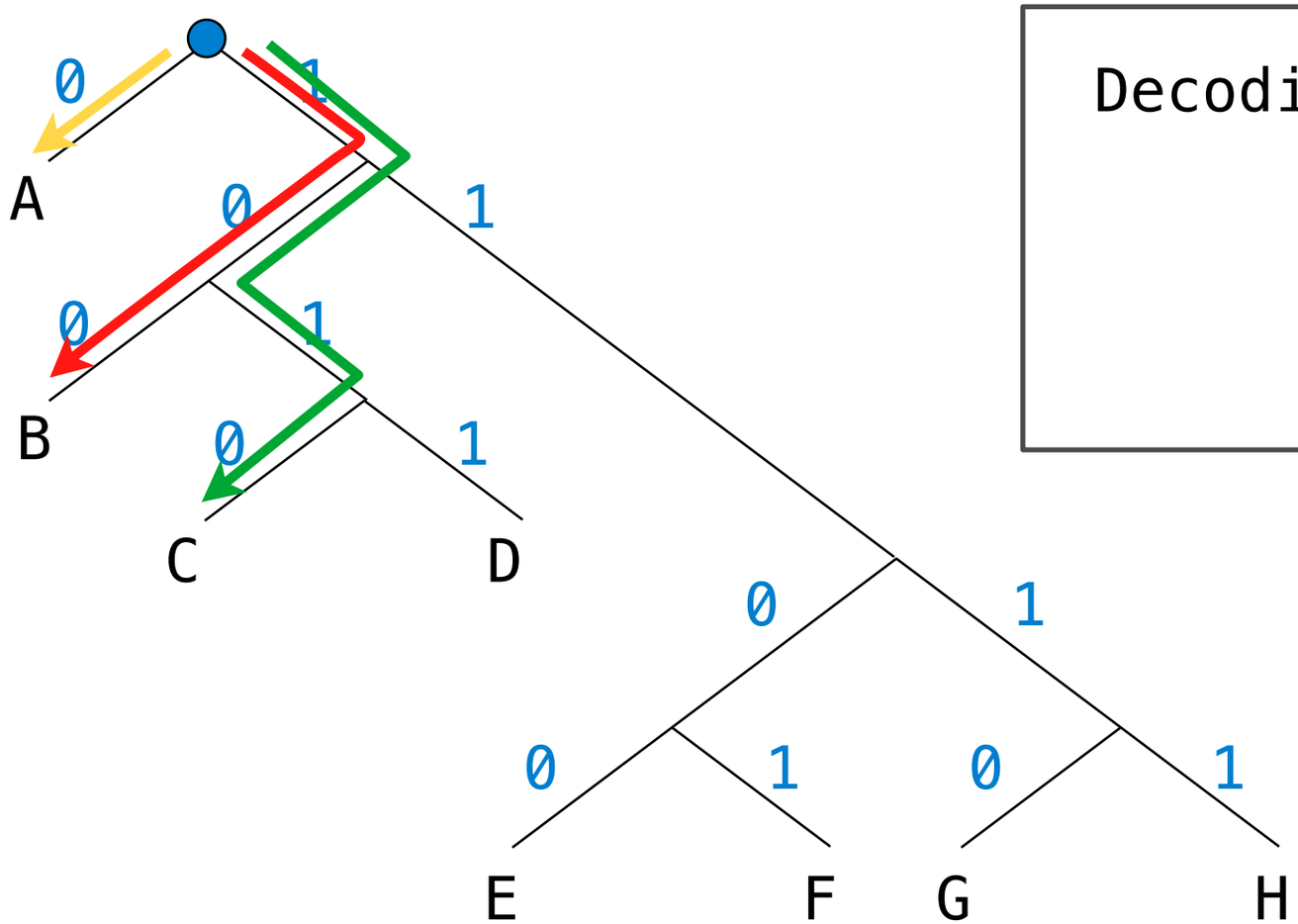
Logo Examples

Demo

Homework: Huffman Encoding Trees

Efficient encoding of strings as ones and zeros (bits).

A 0	C 1010	E 1100	G 1110
B 100	D 1011	F 1101	H 1111



Decoding a sequence of bits:

1 0 0 0 1 0 1 0

B A C