Lecture 4: Programming with Data

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Menu

- Evaluation Question from Monday
- Programming with Data
- Take Pictures

(square 4)

Eval Rule 3a: Application

square — Eval Rule 2: Names

4 — Eval Rule 1: Primitive

(lambda (x) (* x x)) **4** — Eval Rule 3b: Application

Apply Rule 2: Compound Application

(* **4 4**) — Eval Rule 3a: Application

* **4** **4** — Eval Rule 1: Primitive — Eval Rule 1: Primitive

#<primitive:*> 4 4 — Eval Rule 3b: Application

Apply Rule 1: Primitive Application

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Ways to Design Programs

1. Think about what you want to **do**, and turn that into code.

2. Think about what you need to **represent**, and design your code around that.

Which is better?

History of Scheme

- Scheme [Guy Steele & Gerry Sussman, 1975]
  Guy Steele co-designed Scheme and created the first Scheme interpreter for his 4th year project
  More recently, Steele specified Java [1995]
  - "Conniver" [1973] and "Planner" [1967]
- Based on LISP [John McCarthy, 1958]
  - Based on Lambda Calculus
  - Alonzo Church, 1930s
  - Last few lectures in course

LISP

"**L**ots of **I**nsipid **S**illy **P**arentheses"

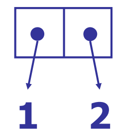
"**LIS**t **P**rocessing language"

Lists are pretty important – hard to write a useful Scheme program without them.

Making Lists

Making a Pair

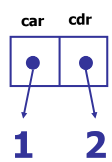
> (**cons** 1 2)
(1 . 2)



cons **cons**tructs a pair

Splitting a Pair

> (**car** (**cons** 1 2))
1
> (**cdr** (**cons** 1 2))
2



car extracts first part of a pair
cdr extracts second part of a pair

Why "car" and "cdr"?

- Original (1950s) LISP on IBM 704
  - Stored cons pairs in memory registers
  - **car** = "**C**ontents of the **A**ddress part of the **R**egister"
  - **cdr** = "**C**ontents of the **D**ecrement part of the **R**egister" ("could-er")
- Doesn't matter unless you have an IBM 704
- Think of them as **first** and **rest**

(define first car)
(define rest cdr)

(The DrScheme "Pretty Big" language already defines these, but they are not part of standard Scheme)

Pairs are fine, but how do we make threesomes?

Triple

A triple is just a pair where one of the parts is a pair!

```
(define (triple a b c)
  (cons a (cons b c)))
(define (t-first t) (car t))
(define (t-second t) (car (cdr t)))
(define (t-third t) (cdr (cdr t)))
```

Quadruple

A quadruple is a pair where the second part is a triple

```
(define (quadruple a b c d)
   (cons a (triple b c d)))
(define (q-first q) (car q))
(define (q-second q) (t-first (cdr t)))
(define (q-third t) (t-second (cdr t)))
(define (q-fourth t) (t-third (cdr t)))
```


Multuples

- A quintuple is a pair where the second part is a quadruple
- A sextuple is a pair where the second part is a quintuple
- A septuple is a pair where the second part is a sextuple
- An octuple is group of octupi
- A ? is a pair where the second part is a …?

Lists

List ::= **(cons** *Element List***)**

A *list* is a pair where the second part is a *list*.

One big problem: how do we stop?
This only allows infinitely long lists!

Lists

List ::= **(cons** *Element List***)**

List ::=

It's hard to write this!

A *list* is either:
 a pair where the second part is a *list*
or, empty

Null

List ::= **(cons** *Element List***)**

List ::= **null**

A *list* is either:
 a pair where the second part is a *list*
or, empty (**null**)

List Examples

```
> null
()
> (cons 1 null)
(1)
> (list? null)
#t
> (list? (cons 1 2))
#f
> (list? (cons 1 null))
#t
```

More List Examples

> (list? (cons 1 (cons 2 null)))
#t
> (car (cons 1 (cons 2 null)))
1
> (cdr (cons 1 (cons 2 null)))
(2)

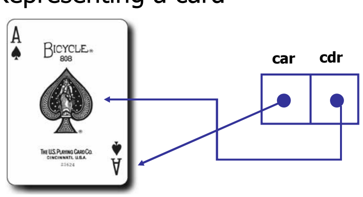
Recap

- A *list* is either:
  a pair where the second part is a *list*
  or **null** (note: book uses **nil**)
- Pair primitives:

(cons a b)	Construct a pair <a, b>
(car pair)	First part of a pair
(cdr pair)	Second part of a pair

Problem Set 2: Programming with Data

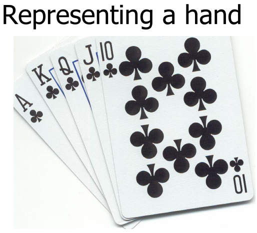
- Representing a card



Pair of rank (Ace) and suit (Spades)

Problem Set 2: Programming with Data

- Representing a card: (cons <rank> <suit>)
- Representing a hand



(list (make-card Ace clubs)
 (make-card King clubs)
 (make-card Queen clubs)
 (make-card Jack clubs)
 (make-card 10 clubs)

Charge

Please don't leave until I take your picture!

- You know everything you need for PS2
- Friday, next week - lots of examples of:
  - Programming with data
  - Programming with procedures
  - Recursive definitions
- But, if you understand the Scheme evaluation rules, you know it all already!