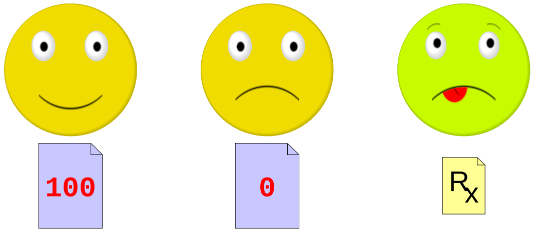
Data So Far

- Built-in atomic data: **`num`**, **`bool`**, **`sym`**, and **`image`**
- Built-in compound data: **`posn`**
- Programmer-defined compound data: **`define-struct`** plus a data definition
- Programmer-defined data with varieties: data definition with "either"

Today: more examples

Example 1: Managing Grades

Suppose that we need to manage exam grades



- Record a grade for each student
- Distinguish zero grade from missing the exam

We want to implement **`passed-exam?`**

Programming with Grades

Data

- Use a number for a grade, obviously
- For a non-grade, use the built-in constant **`empty`**

`empty` is something that you can use to represent nothing.

It's not a **`num`**, **`bool`**, **`sym`**, **`image`**, or **`posn`**.

Programming with Grades

Data

```
; A grade is either
;  - num
;  - empty
```

Examples:

```
100

0

empty
```

Programming with Grades

Contract, Purpose, and Header

```
; passed-exam? : grade -> bool
```

Programming with Grades

Contract, Purpose, and Header

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
```

Programming with Grades

Contract, Purpose, and Header

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
(define (passed-exam? g)
  ...)
```

Programming with Grades

Examples

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
(define (passed-exam? g)
  ...)
```

```
(passed-exam? 100) "should be" true
(passed-exam? 0) "should be" false
(passed-exam? empty) "should be" false
```

Programming with Grades

Template

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
(define (passed-exam? g)
  (cond
    [(number? g) ...]
    [(empty? g) ...]))
```

varieties ⇒ **cond**

```
(passed-exam? 100) "should be" true
(passed-exam? 0) "should be" false
(passed-exam? empty) "should be" false
```

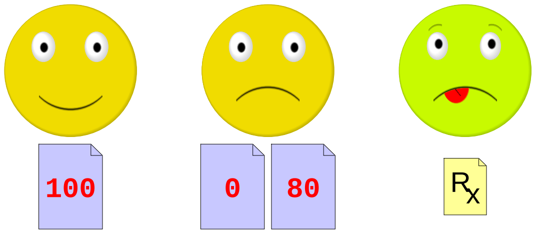
Programming with Grades

Body

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
; (define (passed-exam? g)
;   (cond
;     [(number? g) ...]
;     [(empty? g) ...]))
(define (passed-exam? g)
  (cond
    [(number? g) (>= g 70)]
    [(empty? g) false]))

(passed-exam? 100) "should be" true
(passed-exam? 0) "should be" false
(passed-exam? empty) "should be" false
```

Grades and Re-takes

Suppose that we allow one re-test per student



```
; A grade is either
;  - num
;  - posn
;  - empty
```

Programming with Grades and Retests

Contract, Purpose, and Header

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
(define (passed-exam? g)
  ...)
```

Programming with Grades and Retests

Examples

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
(define (passed-exam? g)
  ...)
```

```
(passed-exam? 100) "should be" true
(passed-exam? (make-posn 0 80)) "should" true
(passed-exam? empty) "should be" false
```

Programming with Grades and Retests

Template

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
(define (passed-exam? g)
  (cond
    [(number? g) ...]
    [(posn? g) ...]
    [(empty? g) ...]))
```

varieties ⇒ cond

```
(passed-exam? 100) "should be" true
(passed-exam? (make-posn 0 80)) "should" true
(passed-exam? empty) "should be" false
```

Programming with Grades and Retests

Template

```
; passed-exam? : grade -> bool
; Determines whether g is 70 or better
(define (passed-exam? g)
  (cond
    [(number? g) ...]
    [(posn? g) ... (posn-passed-exam? g) ...]
    [(empty? g) ...]))
```

data-defn reference ⇒ template reference

```
(passed-exam? 100) "should be" true
(passed-exam? (make-posn 0 80)) "should" true
(passed-exam? empty) "should be" false
```

Complete Function

```
; passed-exam? : grade -> bool
(define (passed-exam? g)
  (cond
    [(number? g) (>= g 70)]
    [(posn? g) (posn-passed-exam? g)]
    [(empty? g) false]))

; posn-passed-exam? : posn -> bool
(define (posn-passed-exam? p)
  (or (>= (posn-x p) 70)
      (>= (posn-y p) 70)))
```

Plus tests and templates...

Shapes of Data and Functions

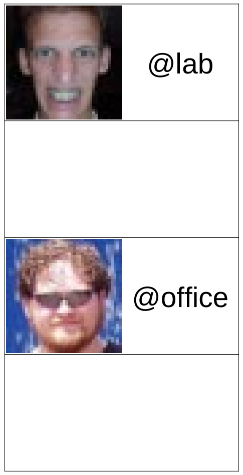
As always, the shape of the function matches the shape of the data

```
; A grade is either
;  - num
;  - posn
;  - empty

; A posn is
;  (make-posn num num)
```

```
(define (func-for-grade g)
  (cond
    [(number? g) ...]
    [(posn? g) ... (func-for-posn g) ...]
    [(empty? g) ...]))

(define (func-for-posn p)
  ... (posn-x p) ... (posn-y p) ..)
```

Example #2: Day Planning

Suppose that we need to manage day-planner entries



Each day-plan is either empty or an appointment with person and place

Implement **close-blinds?**

for Adam's sensitive eyes during office meetings

Programming with Day-Plans

Data

```
; An day-plan is either
;  - empty
;  - (make-appt image sym)
(define-struct appt (who where))
```

Examples:

`empty`

(make-appt 'office)

Programming with Day-Plans

Contract, Purpose, and Header

```
; close-blinds? : day-plan -> bool
```

Programming with Day-Plans

Contract, Purpose, and Header

```
; close-blinds? : day-plan -> bool
; Determines whether dp is a meeting
; with Adam at office
```

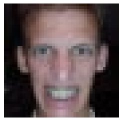
Programming with Day-Plans

Contract, Purpose, and Header

```
; close-blinds? : day-plan -> bool
; Determines whether dp is a meeting
; with Adam at office
(define (close-blinds? dp)
  ...)
```

Programming with Day-Plans

Examples

```
; close-blinds? : day-plan -> bool
; Determines whether dp is a meeting
; with Adam at office
(define (close-blinds? dp)
  ...)
(close-blinds? empty) "should be" false
(close-blinds? (make-appt ’office))
"should be" true
(close-blinds? (make-appt  ’lab))
"should be" false
```

Programming with Day-Plans

Template

```
; close-blinds? : day-plan -> bool
; Determines whether dp is a meeting
; with Adam at office
(define (close-blinds? dp)
  ...)
```

```
; An day-plan is either
;   - empty
;   - (make-appt image sym)
```

Programming with Day-Plans

Template

```
; close-blinds? : day-plan -> bool
; Determines whether dp is a meeting
; with Adam at office
(define (close-blinds? dp)
  (cond
   [(empty? dp) ...]
   [(appt? dp) ...]))
```

varieties ⇒ **cond**

```
; An day-plan is either
;  - empty
;  - (make-appt image sym)
```

Programming with Day-Plans

Template

```
; close-blinds? : day-plan -> bool
; Determines whether dp is a meeting
; with Adam at office
(define (close-blinds? dp)
  (cond
   [(empty? dp) ...]
   [(appt? dp)
    ... (appt-who dp)
    ... (appt-where dp) ...]))
```

compound data ⇒ extract parts

```
; An day-plan is either
;  - empty
;  - (make-appt image sym)
```

Programming with Day-Plans

Body

```
; close-blinds? : day-plan -> bool
; Determines whether dp is a meeting
; with Adam at office
(define (close-blinds? dp)
  (cond
   [(empty? dp) false]
   [(appt? dp)
    (and


     (image=? (appt-who dp)  )
     (symbol=? (appt-where dp) ’office))]))
```

Shapes of Data and Functions

As always, the shape of the function matches the shape of the data

```
; An day-plan is either
;  - empty
;  - (make-appt image sym)
```

```
(define (close-blinds? dp)
  (cond
   [(empty? dp) ...]
   [(appt? dp)
    ... (appt-who dp)
    ... (appt-where dp) ...]))
```

Summary

Today’s examples show:

- A data definition with variants need not involve structure choices
- A data definition with variants can include `make-`*something* directly

  ... usually when the structure by itself isn’t useful
- Implementation shape still matches the data shape

No recipe changes!