Procedural *vs* Functional Style

procedural = imperative

Abstracting Expressions

- Scale a 2D-point `p` by a factor `c`

```
(define scale
  (lambda (c p)
      (cons
            (* c (first p))
            (list (* c (second p)))
      )
))
```

- Can abbreviate a fixed and finite number of function applications for readability, modifiability, and reusability.

Procedural/Imperative *vs* Functional

- *Program*: a sequence of instructions for a von Neumann m/c.
- Computation by instruction execution.
- *Repetition*: Iteration.
- Modifiable or updateable variables.

- *Program*: a collection of function definitions (m/c independent).
- Computation by term rewriting.
- *Repetition*: Recursion.
- *"Assign-only-once"* variables.

Functional Style : Illustration

- Definition : *Equations*

```
sum(0)  = 0
sum(n)  =  n + sum(n-1)
```

- Computation : *Substitution* and *Replacement*

```
      sum(2)
=    2 + sum (2-1)
=    …
=    3
```

Paradigm *vs* Language

- Procedural Style

```
i := 0;   sum := 0;
while (i < n) do
begin
     i := i + 1;
   sum := sum + i
end;
```

  – Storage efficient

- Functional Style

```
func sum(n:int) : int;
begin
   if n = 0 then  0
   else n + sum(n-1)
end;
```

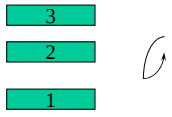
  – No Side-effect

Role of Variables

- *Imperative (read/write)*

i		0	1	2	3	...
sum		0	1	3	6	...

- *Functional (read only)*



Bridging the Gap

- A ***tail recursive*** definition can be automatically optimized for space by translating it into an equivalent `while`-loop.

```
func sum(n : int, r : int) : int;
begin
      if  n = 0   then   r
      else   sum(n-1, n+r)
end
```

  – So, Scheme does not have loop-constructs.

Iteration *vs* Recursion

Recursion = Iteration + Stack

Iteration = Tail Recursion