Collection controlled repetition

- Many languages have convenience structures for collection controlled repetition
- Often called foreach or similar
- General pseudocode:

```
for each item in collection
    do something
```

R: `for` is collection controlled

R's for structure is actually collection controlled repetition, a special case of counter controlled repetition

an expression that evaluates to a collection

```
for ( item in collection ) {
    expression
}
```

item will in turn be assigned the value of each element in the collection

R: `for` is collection controlled

Example

```
a <- c(0.51,0.57,0.09,1.02,1.10)
for ( number in a ) {
    print(number * 2)
}
```

item collection

R: `for` is collection controlled

Example

```
a <- c(0.51,0.57,0.09,1.02,1.10)
for ( number in a ) {
    print(number * 2)
}
```

item collection

a
0.51
0.57
0.09
1.02
1.10

"number" is in turn each element of a

R: `for` is collection controlled

Example

```
a <- c(0.51,0.57,0.09,1.02,1.10)
for ( number in a ) {
    print(number * 2)
}
```

item collection

loop 1

a
0.51
0.57
0.09
1.02
1.10

"number" is in turn each element of a

R: `for` is collection controlled

Example

```
a <- c(0.51,0.57,0.09,1.02,1.10)
for ( number in a ) {
    print(number * 2)
}
```

item collection

loop 2

a
0.51
0.57
0.09
1.02
1.10

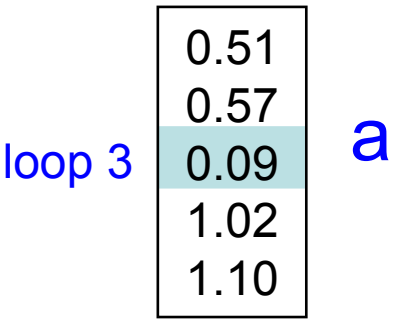
"number" is in turn each element of a

R: `for` is collection controlled

Example

```
a <- c(0.51,0.57,0.09,1.02,1.10)
for ( number in a ) {
    print(number * 2)
}
```

item collection



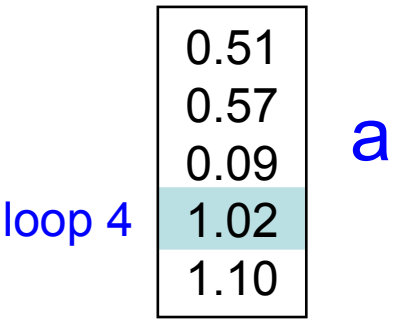
"number" is in turn each element of a

R: `for` is collection controlled

Example

```
a <- c(0.51,0.57,0.09,1.02,1.10)
for ( number in a ) {
    print(number * 2)
}
```

item collection



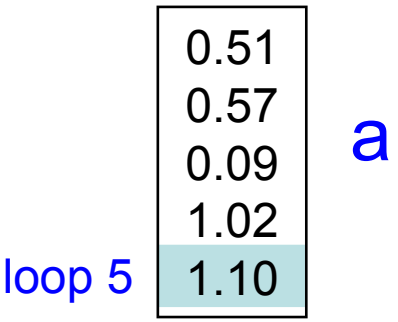
"number" is in turn each element of a

R: `for` is collection controlled

Example

```
a <- c(0.51,0.57,0.09,1.02,1.10)
for ( number in a ) {
    print(number * 2)
}
```

item collection



"number" is in turn each element of a

R: `for` is collection controlled

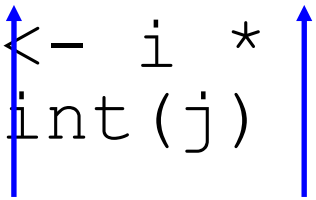
Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

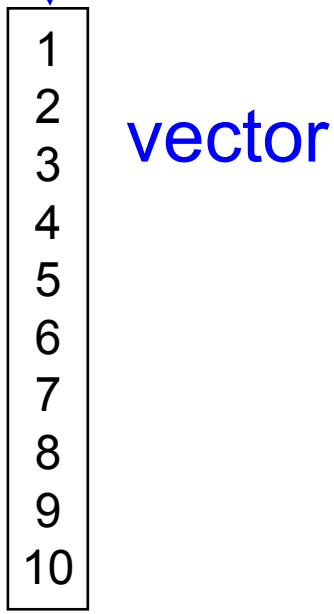


R: `for` is collection controlled

Example revisited

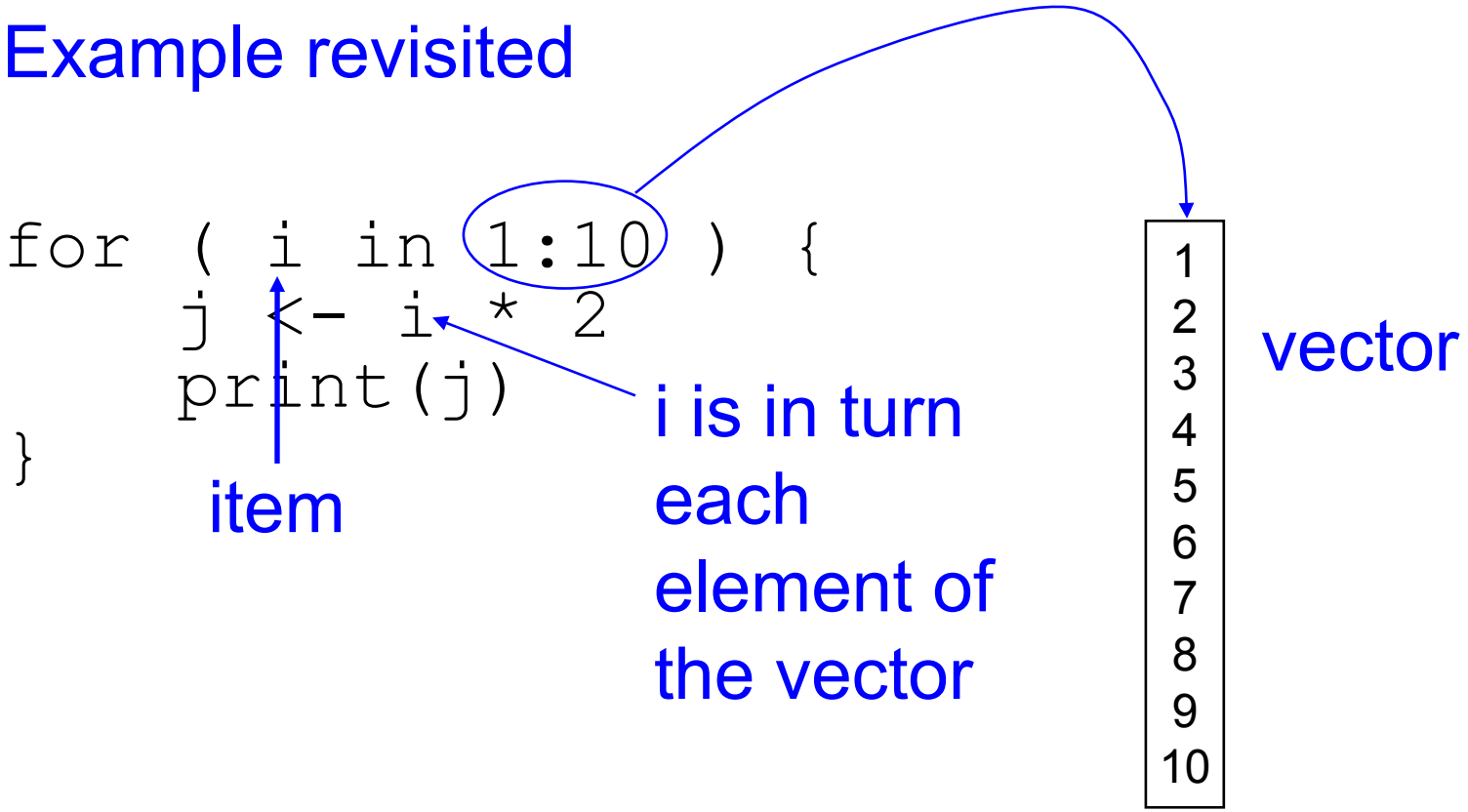
```
for ( i in 1:10 ) {
      j <- i * 2
      print(j)
}
```

item collection



R: `for` is collection controlled

Example revisited

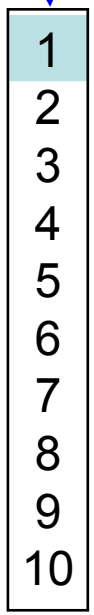


R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector



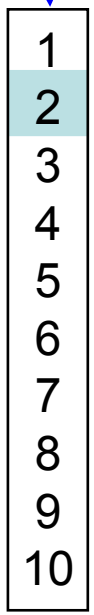
vector

R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector



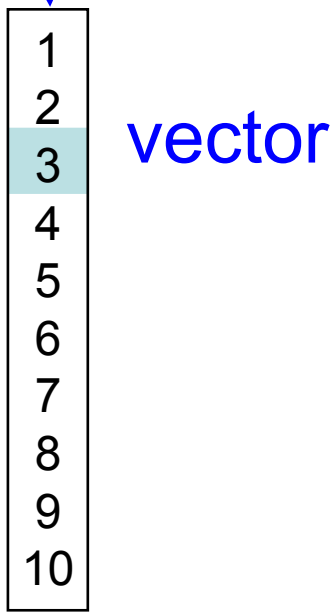
vector

R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector

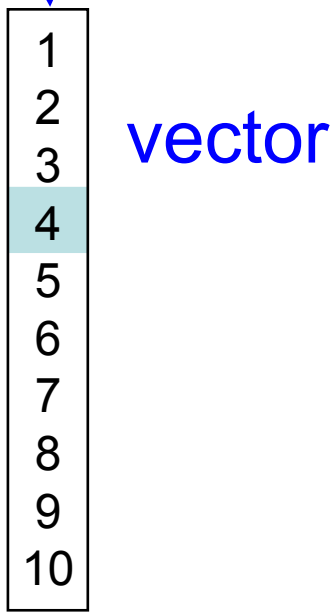


R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector



R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector

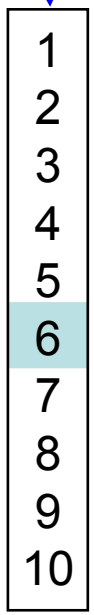
vector

R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector



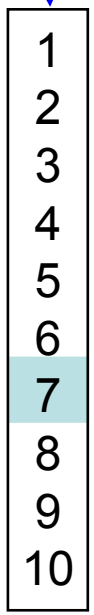
vector

R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector



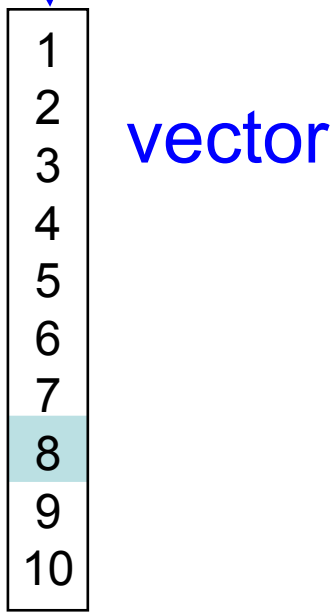
vector

R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector

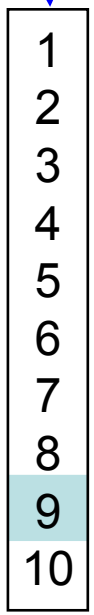


R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector



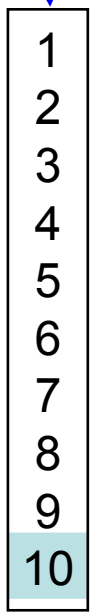
vector

R: `for` is collection controlled

Example revisited

```
for ( i in 1:10 ) {
    j <- i * 2
    print(j)
}
```

i is in turn each element of the vector



vector

Collection controlled repetition

Collection controlled repetition is a special case of counter controlled repetition

```
v #vector
n <- length(v)
i <- 1
while ( i <= n ) {
    expression using v[i]
    i <- i + 1
}
```

get vector length

index vector elements

optional

Data structure: list

- Collection of objects
- Can be heterogeneous

R: collection control with lists

List
- special type of vector
- container for multiple objects

creates a list

```
mylist <- list(obj1,obj2,obj3)
for ( object in mylist ) {
    expression
}
```

could do something to or with the object (or not)

R: collection control with lists

Example

a, b, c, d
are numerical
vectors

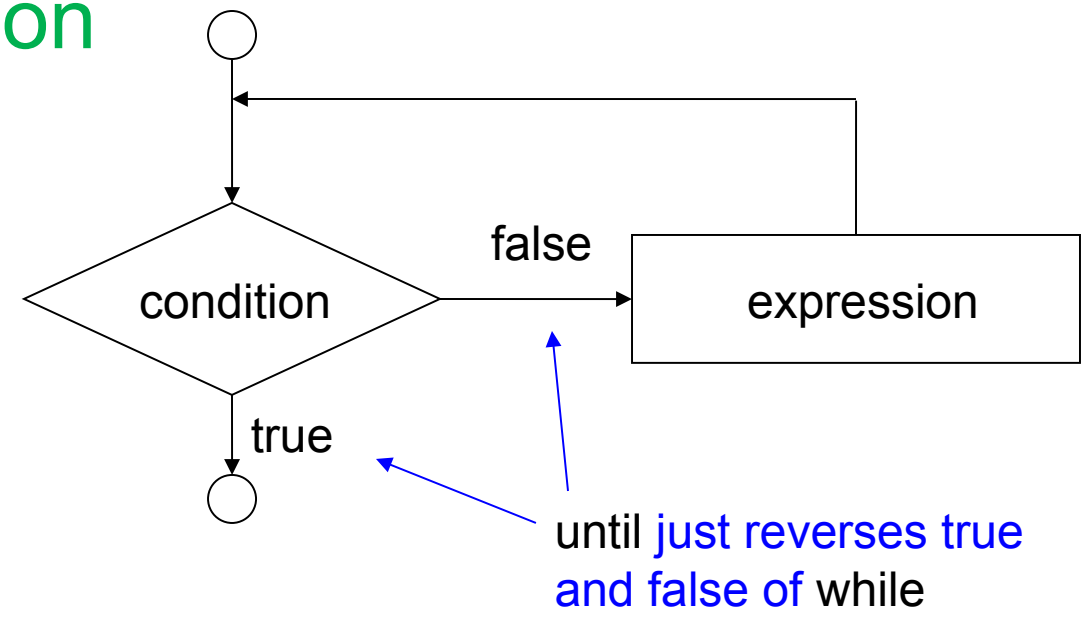
```
datasets <- list(a,b,c,d)
for ( x in datasets ) {
    hist(x)
}
```

What does this do?

until sentinel control

- Many languages have an until structure
- General (non-R) syntax:

```
until ( condition ) {
    expression
}
```

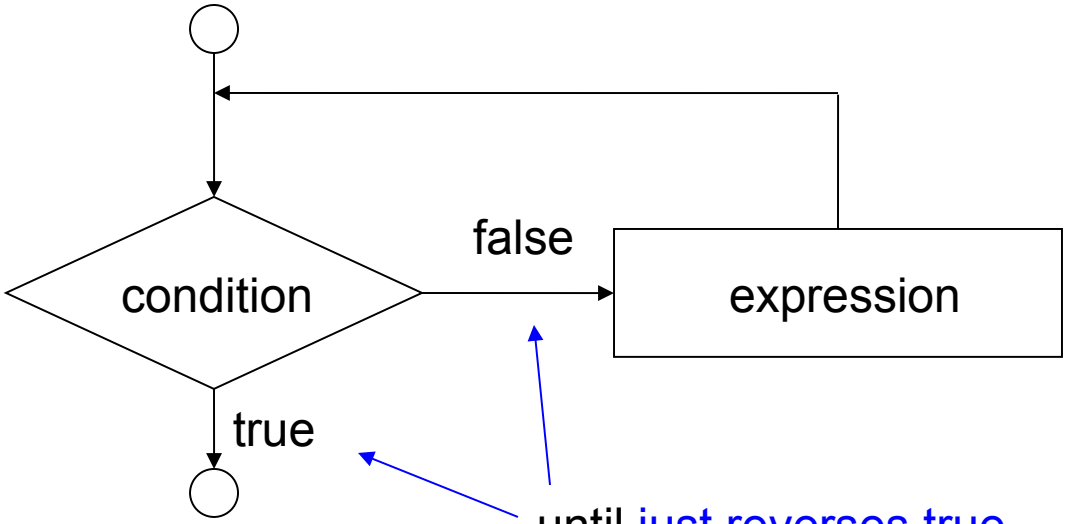


until sentinel control

- In R:

```
while ( !condition ) {
    expression
}
```

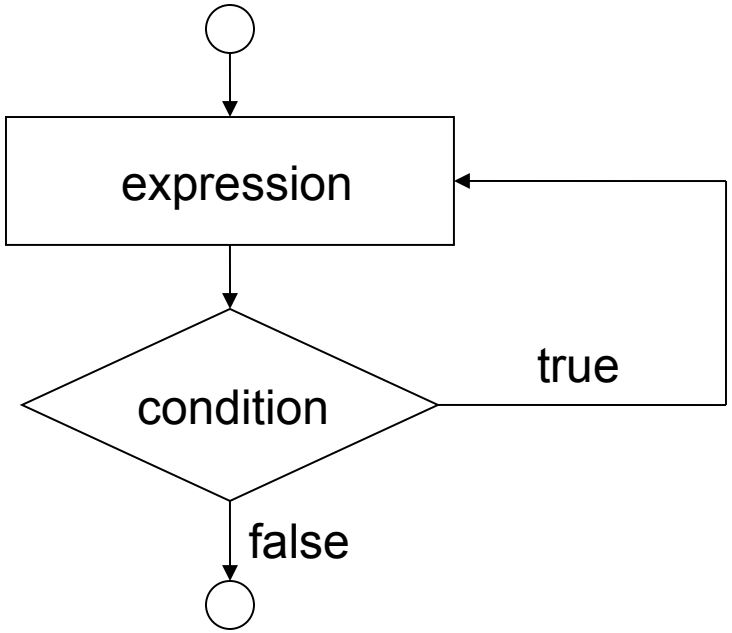
NOT operator
see ?Logic



do-while sentinel control

- Do action at least once before evaluating the condition
- General (non-R) syntax:

```
do {
    expression
} while ( condition )
```



do-while sentinel control

- How to do this in R

Option 1

```
expression
while ( condition ) {
   expression
}
```

Advantage: clear expression is evaluated at least once
Disadvantage: duplicate expression (esp. multiple lines)

do-while sentinel control

- How to do this in R

Option 2 – use a flag

```
first <- TRUE
while ( condition | first ) {
      expression
      if ( first ) first <- FALSE
}
```

Advantage: uses a proper while structure (“goto”-less)
Disadvantage: long and clunky, slight performance hit

do-while sentinel control

- How to do this in R

Option 3 – goto style

infinite loop

```
while ( TRUE ) {
    expression
    if ( !condition ) break
}
```

"break out of the while structure"

Disadvantages: - unintuitive while statement
- break is goto style

do-while sentinel control

- The recommended way in R

Option 4 – R's repeat repetition structure

```
repeat {
    expression
    if ( !condition ) break
}
```

Advantage: clear, concise, no performance hit
Disadvantage: goto style; repeat is not universal

goto keywords

- Use sparingly and with care
- `break`
- `next`
- see ?Control
- Sometimes useful
  - performance
  - readability (to avoid if nested in a loop)

break

goto style

```
for ( i in 1:n ) {
    expression 1
    if ( condition ) break
    expression 2
}
```

Advantage: clearer if code is short and break stands out.

Disadvantage: we don't expect repetition structures to exit early.

structured style for

```
done <- FALSE
for ( i in 1:n ) {
    if ( !done ) {
        expression 1
        if ( condition ) {
            done <- TRUE
        } else {
            expression 2
        }
    }
}
```

Disadvantages: long; deep nested expressions; for does all n

break

goto style

```
for ( i in 1:n ) {
    expression 1
    if ( condition ) break
    expression 2
}
```

Advantage: clearer if code is short and break stands out.

Disadvantage: we don't expect repetition structures to exit early.

structured style while

```
done <- FALSE
i <- 1
while ( !done | i <= n ) {
    expression 1
    if ( condition ) {
        done <- TRUE
    } else {
        expression 2
    }
    i <- i + 1
}
```

Disadvantages: long; nested expression 2

next (or non-R continue)

goto style

```
for ( i in 1:n ) {
    expression 1
    if ( condition ) next
    expression 2
}
```

Advantage: expression 2 is not nested.

Disadvantage: we don't expect repetition structures to exit early.

structured style for

```
for ( i in 1:n ) {
    expression 1
    if ( !condition ) {
        expression 2
    }
}
```

Advantage: structured, still clear.

Disadvantage: hardly any; nested expression 2.

Theory: while is fundamental

All repetition structures can be built from while

Fundamental

```
while (condition){
   expression
}
```

Counter control

```
n #Number of reps
i <- 1
while (i <= n) {
   expression
   i <- i + 1
}
```

Collection control

```
v #A vector
n <- length(v)
i <- 1
while (i <= n) {
   expression on v[i]
   i <- i + 1
}
```

repeat

```
while (TRUE) {
   expression
}
```

until

```
while (!condition) {
   expression
}
```

do-while

```
first <- TRUE
while (condition | first) {
   expression
   if (first) first <- FALSE
}
```

R repetition structures in practice

while sentinel control

```
while ( condition ) {
   expression
}
```

for counter control

```
for ( i in 1:n ) {
    expression
}
```

until sentinel control

```
while ( !condition ) {
   expression
}
```

foreach collection control

```
for ( item in collection ) {
    expression
}
```

do-while sentinel control (e.g. option 4)

```
repeat {
    expression
    if ( !condition ) break
}
```