



4. Data manipulation

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Merging and matching

The data for an analysis often do not come in a single file – so combining multiple files is necessary.

If two data sets have the same individuals in the same order, they *could* simply be pasted together side by side;

```
## CHS baseline data
baseline <- read.spss("I:/DISTRIB/BASEBOTH.SAV", to.data.frame=TRUE)
## Events data (eg death, heart attack, ...)
events <- read.spss("I:/SAVEFILES/EVSUM04.SAV", to.data.frame=TRUE)

if (!all(baseline$IDNO==events$IDNO)) {
  stop("PANIC: They don't match!")
} else {
  alldata <- cbind(baseline, events[,c("TTODTH", "DEATH",
    "TTOMI", "INCMI")])
}
```

Merging: order

The data might need to be sorted first;

```
index1 <- order(baseline$IDNO)
baseline <- baseline[index1,]
index2 <- order(events$IDNO)
events <- events[index2,]
if (!all(baseline$IDNO==events$IDNO)) {
  stop("PANIC: They still don't match!")
} else {
  alldata <- cbind(baseline, events[,c("TTODTH", "DEATH",
    "TTOMI", "INCMI")])
}
```

Note that `order(baseline$IDNO)=` gives a subset of row numbers containing all the rows but in a different (increasing) order.

Merging: merge

Or there might be different rows in the two data sets;

- Some people are missing from one or other data set (eg baseline and year 5 visits)
- Some people have multiple records in one data set (eg baseline data and all hospitalisations)

The `merge()` function can do an **database outer join**, giving a data set that has all the possible matches between a row in one and a row in the other. This saves a lot of effort!

Merging: merge

```
combined <- merge(baseline, hospvisits, by="IDNO", all=TRUE)
```

- `"by=IDNO"` says that the IDNO variable indicates individuals who should be matched.
- `"all=TRUE"` says that even people with no records in the `hospvisits` data set should be kept in the merged version.

See `?merge` for other options.

How does it work: match

You could imagine a dumb algorithm for merging

```
for(row in firstdataset){
  for(otherrow in seconddataset){
    if (row$IDNO==otherrow$IDNO)
      ##add the row to the result
  }
}
```

More efficiently, the `match()` function gives indices to match one variable to another;

```
> match(c("B","I","O","S","T","A","T"),LETTERS)
[1]  2  9 15 19 20  1 20
> letters[match(c("B","I","O","S","T","A","T"),LETTERS)]
[1] "b" "i" "o" "s" "t" "a" "t"
```

Reshaping

Sometimes data sets are the wrong shape. Data with multiple observations of similar quantities can be in **long** form (multiple records per person) or **wide** form (multiple variables per person).

Example: The SeattleSNPs genetic variation discovery resource supplies data in a format

```
SNP    sample a11 a12
000095 D001  C  T
000095 D002  T  T
000095 D003  T  T
```

so that data for a single person is broken across many lines. To convert this to one line per person...

Reshaping

```
> data<-read.table("http://pga.gs.washington.edu/data/il6
                  /ilkn6.prettybase.txt",
                  col.names=c("SNP","sample","allele1","allele2"))
> dim(data)
[1] 2303    4
> wideData<-reshape(data, direction="wide", idvar="sample",
                    timevar="SNP")
> dim(wideData)
[1] 47 99
> names(wideData)
[1] "sample"      "allele1.95"   "allele2.95"   "allele1.205"
[5] "allele2.205" "allele1.276" "allele2.276" "allele1.321"
[9] "allele2.321" "allele1.657" "allele2.657" "allele1.1086"
...
```


Reshaping

- `direction="wide"` says we are going from long to wide format
- `idvar="sample"` says that `sample` identifies the rows in wide format
- `timevar="SNP"` says that `SNP` identifies which rows go into the same column in wide form (for repeated measurements over time it would be the time variable)

Broken down by() age and sex

A common request for Table 1 or Table 2 in a medical paper is to compute means and standard deviations, percentages, or frequency tables of many variables broken down by groups (eg case/control status, age and sex, exposure,...).

That is, we need to apply a simple computation to subsets of the data, and apply it to many variables. One useful function is `by()`, another is `tapply()`, which is very similar (but harder to remember).

```
> by(airquality$Ozone, list(month=airquality$Month),  
      mean, na.rm=TRUE)
```

```
month: 5
```

```
[1] 23.61538
```

```
-----
```

```
month: 6
```

```
[1] 29.44444
```

```
-----
```

```
month: 7
```

```
[1] 59.11538
```

```
-----
```

```
month: 8
```

```
[1] 59.96154
```

```
-----
```

```
month: 9
```

```
[1] 31.44828
```

Notes

- The first argument is the variable to be analyzed.
- The second argument is a list of variable defining subsets. In this case, a single variable, but we could do `"list(month=airquality$Month, toohot=airquality$Temp>85)"` to get a breakdown by month and temperature
- The third argument is the analysis function to use on each subset
- Any other arguments (`na.rm=TRUE`) are also given to the analysis function
- The result is really a vector (with a single grouping variable) or array (with multiple grouping variables). It prints differently.

Confusing digression: str()

How do we know it is an array? Because `str()` summarises the internal structure of a variable.

```
> a<- by(airquality$Ozone, list(month=airquality$Month,
                               toohot=airquality$Temp>85),
        mean, na.rm=TRUE)
```

```
> str(a)
by [1:5, 1:2] 23.6 22.1 49.3 40.9 22.0 ...
- attr(*, "dimnames")=List of 2
  ..$ month : chr [1:5] "5" "6" "7" "8" ...
  ..$ toohot: chr [1:2] "FALSE" "TRUE"
- attr(*, "call")= language by.data.frame(data =
  as.data.frame(data), INDICES = INDICES,
  FUN = FUN, na.rm = TRUE)
- attr(*, "class")= chr "by"
```

One function, many variables

There is a general function, `apply()` for doing something to rows or columns of a matrix (or slices of a higher-dimensional array).

```
> apply(psa[,1:8],2,mean,na.rm=TRUE)
```

id	nadir	pretx	ps	bss
25.500000	16.360000	670.751163	80.833333	2.520833
grade	age	obstime		
2.146341	67.440000	28.460000		

In this case there is a special, faster, function `colMeans`, but `apply()` can be used with other functions such as `sd()`, `IQR()`, `min()`,...

apply

- the first argument is an array or matrix or dataframe
- the second argument says which margins to keep (1=rows, 2=columns, ...), so 2 means that the result should keep the columns: apply the function to each column.
- the third argument is the analysis function
- any other arguments are given to the analysis function

There is a widespread belief that `apply()` is faster than a `for()` loop over the columns. This is a useful belief, since it encourages people to use `apply()`, but it is not true. (We'll see `for()` loops later)

New functions

Suppose you want the mean and standard deviation for each variable. One solution is to apply a new function;

```
> apply(psa[,1:8], 2,  
       function(x){c(mean=mean(x,na.rm=TRUE), stddev=sd(x,na.rm=TRUE))}  
       )
```

```
          id  nadir  pretx      ps      bss      grade  
mean  25.50000 16.3600 670.7512 80.83333 2.5208333 2.1463415  
stddev 14.57738 39.2462 1287.6384 11.07678 0.6838434 0.7924953  
          age  obstime  
mean  67.440000 28.46000  
stddev  5.771711 18.39056
```


New functions

```
function(x){ c(mean=mean(x,na.rm=TRUE), stddev=sd(x,na.rm=TRUE)) }
```

translates as: “If you give me a vector, which I will call `x`, I will mean it and sd it and give you the results”

We could give this function a name and then refer to it by name

```
mean.and.sd <- function(x){ c(mean=mean(x,na.rm=TRUE),  
                             stddev=sd(x,na.rm=TRUE))  
                             }  
apply(psa[,1:8], 2, mean.and.sd)
```

which would save typing if we used the function many times. The {curly brackets} are optional for a function with just one expression, but necessary for longer functions.

by() revisited

With our own functions, we can use `by()` more generally

```
> by(psa[,1:8], list(remission=psa$inrem),
     function(subset){round( apply(subset, 2, mean.and.sd), 2)} )
remission: no
      id nadir  pretx    ps  bss grade  age obstime
mean  31.03 22.52 725.99 79.71 2.71  2.11 67.17  21.75
stddev 11.34 44.91 1362.34 10.29 0.52  0.83  5.62  15.45
-----
remission: yes
      id nadir  pretx    ps  bss grade  age obstime
mean  11.29  0.53 488.45 83.57 2.07  2.23 68.14  45.71
stddev 12.36  0.74 1044.14 12.77 0.83  0.73  6.30  13.67
```

Notes

```
function(subset){ round(apply(subset, 2, mean.and.sd), 2) }
```

translates as “If you give me a data frame, which I will call `subset`, I will apply the `mean.and.sd` function to each variable, round to 2 decimal places, and give you the results”