

Using the reshape function

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1 Introduction

The `reshape()` function reshapes datasets in the so-called ‘wide’ format (with repeated measurements in separate columns of the same row) to the ‘long’ format (with the repeated measurements in separate rows), and vice versa.

`reshape()` is a somewhat complicated function, and this vignette gives a few examples of how it can be used. Although `reshape()` can be used in a variety of contexts, the motivating application is data from longitudinal studies, and the arguments of this function are named and described in those terms. See the documentation (`help(reshape)`) for background and detailed usage.

For our examples, we will simulate data from a study where individuals are measured at two time points. Two of the measurements are time-varying: height and weight, and one of the measurements is time-constant: sex.

2 Conversion from wide to long format

We first simulate data in the wide format. Data from each individual is contained in one row, with one column for time-constant variables and multiple columns for time-varying variables. Here there are two time points (before and after), so there are two columns for each time-varying variable.

```
> set.seed(12345)
> n <- 5
> d1 <- data.frame(sex = sample(c("M", "F"), n, rep = TRUE),
  ht.before = round(rnorm(n, 165, 6), 1),
  ht.after = round(rnorm(n, 165, 6), 1),
  wt.before = round(rnorm(n, 80, 6)),
  wt.after = round(rnorm(n, 80, 6)))
> d1
```

	sex	ht.before	ht.after	wt.before	wt.after
1	F	159.2	164.4	78	78
2	M	165.1	163.5	81	88
3	F	178.9	175.0	80	73
4	F	158.8	162.3	65	79
5	F	146.7	168.3	83	84

Suppose we want to convert this dataset into the long format, with two rows for each individual, and one column for each variable (both time-constant and time-varying). Such a representation will need two additional variables to distinguish between multiple rows corresponding to the same individual (corresponding to one row in the wide format): a time-variable and an id-variable. These will be automatically created when converting from wide to long format.

However, we do need to specify which columns in the wide format correspond to the same time-varying variable(s). This is easiest to do when we have only one time-varying variable. Although we have two such in our example, let us pretend that only height is time-varying. The corresponding columns can be specified as the `varying` argument. The two weight variables will then be assumed to be different time-constant variables, similar to sex.

```
> reshape(d1, direction = "long",
           varying = c("ht.before", "ht.after"))
```

	sex	wt.before	wt.after	time	ht	id
1.before	F	78	78	before	159.2	1
2.before	M	81	88	before	165.1	2
3.before	F	80	73	before	178.9	3
4.before	F	65	79	before	158.8	4
5.before	F	83	84	before	146.7	5
1.after	F	78	78	after	164.4	1
2.after	M	81	88	after	163.5	2
3.after	F	80	73	after	175.0	3
4.after	F	65	79	after	162.3	4
5.after	F	83	84	after	168.3	5

It is equivalent to specify the variables as column indices.

```
> reshape(d1, direction = "long",
           varying = c(2, 3))
```

	sex	wt.before	wt.after	time	ht	id
1.before	F	78	78	before	159.2	1
2.before	M	81	88	before	165.1	2
3.before	F	80	73	before	178.9	3
4.before	F	65	79	before	158.8	4
5.before	F	83	84	before	146.7	5
1.after	F	78	78	after	164.4	1
2.after	M	81	88	after	163.5	2
3.after	F	80	73	after	175.0	3
4.after	F	65	79	after	162.3	4
5.after	F	83	84	after	168.3	5

Note that the names of the combined variable, as well as the values of the time variable, are automatically detected because the names happen to be “nicely” formatted. Suppose we instead had

```
> n <- 5
> d2 <- data.frame(sex = sample(c("M", "F"), n, rep = TRUE),
```

```

ht_before = round(rnorm(n, 165, 6), 1),
ht_after = round(rnorm(n, 165, 6), 1),
wt_before = round(rnorm(n, 80, 6)),
wt_after = round(rnorm(n, 80, 6))

```

Modifying the previous call gives:

```

> try(
  reshape(d2, direction = "long",
    varying = c("wt_before", "wt_after")),
)

```

```

Error in guess(varying) :
  failed to guess time-varying variables from their names

```

This is easy to “fix” in this case because the names are still nicely formatted, just not using the separator that `reshape()` expects by default.

```

> reshape(d2, direction = "long",
  varying = c("wt_before", "wt_after"), sep = "_")

```

	sex	ht_before	ht_after	time	wt	id
1.before	F	175.8	169.9	before	83	1
2.before	M	162.1	178.2	before	78	2
3.before	F	168.7	177.3	before	70	3
4.before	M	168.7	174.8	before	91	4
5.before	F	164.0	166.5	before	80	5
1.after	F	175.8	169.9	after	87	1
2.after	M	162.1	178.2	after	66	2
3.after	F	168.7	177.3	after	74	3
4.after	M	168.7	174.8	after	86	4
5.after	F	164.0	166.5	after	85	5

A more general solution is to specify the name of the new combined column explicitly as the `v.names` argument.

```

> reshape(d2, direction = "long",
  varying = c("wt_before", "wt_after"),
  v.names = "weight")

```

	sex	ht_before	ht_after	time	weight	id
1.1	F	175.8	169.9	1	83	1
2.1	M	162.1	178.2	1	78	2
3.1	F	168.7	177.3	1	70	3
4.1	M	168.7	174.8	1	91	4
5.1	F	164.0	166.5	1	80	5
1.2	F	175.8	169.9	2	87	1
2.2	M	162.1	178.2	2	66	2
3.2	F	168.7	177.3	2	74	3
4.2	M	168.7	174.8	2	86	4
5.2	F	164.0	166.5	2	85	5

We can additionally specify the names and values of the id / time variables as well.

```
> reshape(d2, direction = "long",
          varying = c("wt_before", "wt_after"),
          v.names = "weight",
          timevar = "when", times = c("pre", "post"),
          idvar = "subject", ids = letters[1:n])
```

	sex	ht_before	ht_after	when	weight	subject
a.pre	F	175.8	169.9	pre	83	a
b.pre	M	162.1	178.2	pre	78	b
c.pre	F	168.7	177.3	pre	70	c
d.pre	M	168.7	174.8	pre	91	d
e.pre	F	164.0	166.5	pre	80	e
a.post	F	175.8	169.9	post	87	a
b.post	M	162.1	178.2	post	66	b
c.post	F	168.7	177.3	post	74	c
d.post	M	168.7	174.8	post	86	d
e.post	F	164.0	166.5	post	85	e

Note that the `times` argument is ignored when automatic guessing is performed, i.e., when `v.names` is not explicitly specified.

```
> reshape(d2, direction = "long",
          varying = c("wt_before", "wt_after"), sep = "_",
          ## v.names = "wt", # without this, 'times' is unused
          timevar = "when", times = c("pre", "post"))
```

	sex	ht_before	ht_after	when	wt	id
1.before	F	175.8	169.9	before	83	1
2.before	M	162.1	178.2	before	78	2
3.before	F	168.7	177.3	before	70	3
4.before	M	168.7	174.8	before	91	4
5.before	F	164.0	166.5	before	80	5
1.after	F	175.8	169.9	after	87	1
2.after	M	162.1	178.2	after	66	2
3.after	F	168.7	177.3	after	74	3
4.after	M	168.7	174.8	after	86	4
5.after	F	164.0	166.5	after	85	5

So far, we have only specified one time-varying variable, but our data actually has two. How do we specify multiple time-varying variables? This depends on whether the variable names are in a guessable format.

2.1 Explicitly specifying variables names

The general approach is to explicitly specify both `varying` and `v.names` as before. `v.names` should be a vector of new variable names in the long format, and `varying` should either be a list, with each component giving the corresponding wide format variable names, or a matrix, with each row giving the corresponding wide format variable names.

```
> reshape(d2, direction = "long",
          varying = list(c("ht_before", "ht_after"),
                        c("wt_before", "wt_after")), # list form
          v.names = c("height", "weight"),
          times = c("pre", "post"))
```

	sex	time	height	weight	id
1.pre	F	pre	175.8	83	1
2.pre	M	pre	162.1	78	2
3.pre	F	pre	168.7	70	3
4.pre	M	pre	168.7	91	4
5.pre	F	pre	164.0	80	5
1.post	F	post	169.9	87	1
2.post	M	post	178.2	66	2
3.post	F	post	177.3	74	3
4.post	M	post	174.8	86	4
5.post	F	post	166.5	85	5

```
> reshape(d2, direction = "long",
          varying = rbind(c("ht_before", "ht_after"),
                        c("wt_before", "wt_after")), # matrix form
          v.names = c("height", "weight"))
```

	sex	time	height	weight	id
1.1	F	1	175.8	83	1
2.1	M	1	162.1	78	2
3.1	F	1	168.7	70	3
4.1	M	1	168.7	91	4
5.1	F	1	164.0	80	5
1.2	F	2	169.9	87	1
2.2	M	2	178.2	66	2
3.2	F	2	177.3	74	3
4.2	M	2	174.8	86	4
5.2	F	2	166.5	85	5

The `times` argument has been omitted in the second example above, and the default is to use sequential times. The `v.names` argument can be omitted as well, but the default is not generally sensible.

Of course, the time and id variables can also be controlled in the usual way as long as `v.names` is specified.

```
> reshape(d2, direction = "long",
          varying = rbind(c("ht_before", "ht_after"),
                        c("wt_before", "wt_after")),
          v.names = c("height", "weight"),
          timevar = "when",
          times = c("pre", "post"),
          idvar = "subject",
          ids = letters[1:n])
```

	sex	when	height	weight	subject
a.pre	F	pre	175.8	83	a
b.pre	M	pre	162.1	78	b
c.pre	F	pre	168.7	70	c
d.pre	M	pre	168.7	91	d
e.pre	F	pre	164.0	80	e
a.post	F	post	169.9	87	a
b.post	M	post	178.2	66	b
c.post	F	post	177.3	74	c
d.post	M	post	174.8	86	d
e.post	F	post	166.5	85	e

2.2 Variables names in a guessable format

Even when variable names are in a guessable format, `reshape()` will not try to guess if multiple time-varying variables are provided as a list or matrix. However, when the wide format variable names are suitably formatted in the same manner for all time-varying variables, it is still possible to take advantage of automatic guessing by specifying the `varying` argument as an atomic vector (of either names or indices) containing all time-varying columns.

```
> reshape(d2, direction = "long",
           varying = c("ht_before", "ht_after",
                       "wt_before", "wt_after"), sep = "_")
```

	sex	time	ht	wt	id
1.before	F	before	175.8	83	1
2.before	M	before	162.1	78	2
3.before	F	before	168.7	70	3
4.before	M	before	168.7	91	4
5.before	F	before	164.0	80	5
1.after	F	after	169.9	87	1
2.after	M	after	178.2	66	2
3.after	F	after	177.3	74	3
4.after	M	after	174.8	86	4
5.after	F	after	166.5	85	5

The atomic vector form of `varying` can be combined with explicit (non-guessed) specification of `v.names` as well, but in that case, one needs to pay careful attention to the order of variable names in `varying`. The following gives wrong results:

```
> reshape(d2, direction = "long",
           varying = c("ht_before", "ht_after",
                       "wt_before", "wt_after"),
           v.names = c("height", "weight"))
```

	sex	time	height	weight	id
1.1	F	1	175.8	169.9	1
2.1	M	1	162.1	178.2	2
3.1	F	1	168.7	177.3	3
4.1	M	1	168.7	174.8	4

5.1	F	1	164.0	166.5	5
1.2	F	2	83.0	87.0	1
2.2	M	2	78.0	66.0	2
3.2	F	2	70.0	74.0	3
4.2	M	2	91.0	86.0	4
5.2	F	2	80.0	85.0	5

The correct order requires all columns corresponding to the same time to be contiguous; this is the same intrinsic column-major ordering in the matrix form above. It is best to avoid the atomic vector form of `varying` unless `v.names` is being omitted.

2.3 Repeated application of reshape

Just as an illustration, let us try to create an even longer dataset that combines height and weight together in a single column.

```
> dlong <-
  reshape(d2, direction = "long",
    varying = c("ht_before", "wt_before",
      "ht_after", "wt_after"),
    v.names = c("height", "weight"),
    timevar = "when", times = c("pre", "post"),
    idvar = "subject", ids = letters[1:n])
> reshape(dlong, direction = "long",
  varying = c("height", "weight"),
  v.names = "combined",
  timevar = "what", times = c("height", "weight"))
```

	sex	when	subject	what	combined	id
1.height	F	pre	a	height	175.8	1
2.height	M	pre	b	height	162.1	2
3.height	F	pre	c	height	168.7	3
4.height	M	pre	d	height	168.7	4
5.height	F	pre	e	height	164.0	5
6.height	F	post	a	height	169.9	6
7.height	M	post	b	height	178.2	7
8.height	F	post	c	height	177.3	8
9.height	M	post	d	height	174.8	9
10.height	F	post	e	height	166.5	10
1.weight	F	pre	a	weight	83.0	1
2.weight	M	pre	b	weight	78.0	2
3.weight	F	pre	c	weight	70.0	3
4.weight	M	pre	d	weight	91.0	4
5.weight	F	pre	e	weight	80.0	5
6.weight	F	post	a	weight	87.0	6
7.weight	M	post	b	weight	66.0	7
8.weight	F	post	c	weight	74.0	8
9.weight	M	post	d	weight	86.0	9
10.weight	F	post	e	weight	85.0	10

Can we get this directly from `d2` using a single `reshape()` call? We can, except that we will get a composite time variable (which can be easily split if needed).

```
> reshape(d2, direction = "long",
          v.names = "combined",
          varying = c("ht_before", "ht_after", "wt_before", "wt_after"),
          timevar = "when_what",
          times = c("pre_height", "post_height", "pre_weight", "post_weight"),
          idvar = "subject", ids = letters[1:n])
```

	sex	when_what	combined	subject
a.pre_height	F	pre_height	175.8	a
b.pre_height	M	pre_height	162.1	b
c.pre_height	F	pre_height	168.7	c
d.pre_height	M	pre_height	168.7	d
e.pre_height	F	pre_height	164.0	e
a.post_height	F	post_height	169.9	a
b.post_height	M	post_height	178.2	b
c.post_height	F	post_height	177.3	c
d.post_height	M	post_height	174.8	d
e.post_height	F	post_height	166.5	e
a.pre_weight	F	pre_weight	83.0	a
b.pre_weight	M	pre_weight	78.0	b
c.pre_weight	F	pre_weight	70.0	c
d.pre_weight	M	pre_weight	91.0	d
e.pre_weight	F	pre_weight	80.0	e
a.post_weight	F	post_weight	87.0	a
b.post_weight	M	post_weight	66.0	b
c.post_weight	F	post_weight	74.0	c
d.post_weight	M	post_weight	86.0	d
e.post_weight	F	post_weight	85.0	e

3 Conversion from wide to long format

Conversion from long to wide format is generally simpler. Let us simulate long format data from the same hypothetical setup.

```
> d3 <- data.frame(sex = sample(c("M", "F"), 2 * n, rep = TRUE),
                  ht = round(rnorm(2 * n, 165, 6), 1),
                  wt = round(rnorm(2 * n, 80, 6)),
                  subject = rep(1:n, 2),
                  when = rep(c("pre", "post"), each = n))
> d3
```

	sex	ht	wt	subject	when
1	M	161.8	81	1	pre
2	M	176.7	72	2	pre
3	F	165.3	83	3	pre
4	M	167.1	90	4	pre

5	F	161.0	76	5	pre
6	F	166.7	69	1	post
7	F	169.1	85	2	post
8	M	169.9	90	3	post
9	F	177.9	83	4	post
10	F	150.9	72	5	post

To convert this to the wide format, the arguments `idvar` and `timevar` to `reshape()` are mandatory, and all other variables are assumed to be time-varying. This is what we do in the next example, where even `sex` is erroneously treated as time-varying.

```
> reshape(d3, direction = "wide",
           idvar = "subject", timevar = "when")
```

	subject	sex.pre	ht.pre	wt.pre	sex.post	ht.post	wt.post
1	1	M	161.8	81	F	166.7	69
2	2	M	176.7	72	F	169.1	85
3	3	F	165.3	83	M	169.9	90
4	4	M	167.1	90	F	177.9	83
5	5	F	161.0	76	F	150.9	72

To specify some variables as time-constant, the time-varying variables must be explicitly specified through `v.names`.

```
> reshape(d3, direction = "wide",
           idvar = "subject", timevar = "when",
           v.names = c("ht", "wt"))
```

This gives a warning because `sex` is not really time-constant in the dataset we have created. Let us fix that:

```
> n <- 10
> d4 <- data.frame(sex = rep(sample(c("M", "F"), n, rep = TRUE), 2),
                   ht = round(rnorm(2 * n, 165, 6), 1),
                   wt = round(rnorm(2 * n, 80, 6)),
                   subject = rep(1:n, 2),
                   when = rep(c("pre", "post"), each = n))
> reshape(d4, direction = "wide",
           idvar = "subject", timevar = "when",
           v.names = c("ht", "wt"), sep = "_")
```

	sex	subject	ht_pre	wt_pre	ht_post	wt_post
1	F	1	170.7	84	176.2	77
2	F	2	170.0	77	169.0	78
3	F	3	160.1	93	163.2	89
4	F	4	167.9	76	168.2	77
5	M	5	171.1	76	169.9	82
6	F	6	168.9	81	159.2	73
7	F	7	171.3	73	159.9	72
8	M	8	163.2	83	176.3	88
9	M	9	179.9	72	162.6	88
10	F	10	170.8	81	159.1	80

To specify the resulting wide format variable names explicitly instead of using the automatically constructed defaults, we may use the `varying` argument as in wide-to-long conversion. As in that case, `varying` can be a vector of variable names, where the same caveats apply regarding order.

```
> reshape(d4, direction = "wide",
           idvar = "subject", timevar = "when",
           v.names = c("ht", "wt"),
           varying = c("h_before", "w_before", "h_after", "w_after"))
```

	sex	subject	h_before	w_before	h_after	w_after
1	F	1	170.7	84	176.2	77
2	F	2	170.0	77	169.0	78
3	F	3	160.1	93	163.2	89
4	F	4	167.9	76	168.2	77
5	M	5	171.1	76	169.9	82
6	F	6	168.9	81	159.2	73
7	F	7	171.3	73	159.9	72
8	M	8	163.2	83	176.3	88
9	M	9	179.9	72	162.6	88
10	F	10	170.8	81	159.1	80

For more than one time-varying variable, it is safer to avoid the vector form and instead specify `varying` as a list or matrix.

```
> reshape(d4, direction = "wide",
           idvar = "subject", timevar = "when",
           v.names = c("ht", "wt"),
           varying = list(c("h_before", "h_after"),
                         c("w_before", "w_after")))
```

	sex	subject	h_before	w_before	h_after	w_after
1	F	1	170.7	84	176.2	77
2	F	2	170.0	77	169.0	78
3	F	3	160.1	93	163.2	89
4	F	4	167.9	76	168.2	77
5	M	5	171.1	76	169.9	82
6	F	6	168.9	81	159.2	73
7	F	7	171.3	73	159.9	72
8	M	8	163.2	83	176.3	88
9	M	9	179.9	72	162.6	88
10	F	10	170.8	81	159.1	80