

# ReadqPCR: Functions to load RT-qPCR data into R

James Perkins  
University of Malaga

Matthias Kohl  
Furtwangen University

October 24, 2023

## Contents

|          |                     |          |
|----------|---------------------|----------|
| <b>1</b> | <b>Introduction</b> | <b>1</b> |
| <b>2</b> | <b>read.LC480</b>   | <b>2</b> |
| <b>3</b> | <b>read.qPCR</b>    | <b>7</b> |
| <b>4</b> | <b>read.taqman</b>  | <b>8</b> |
| <b>5</b> | <b>qPCRBatch</b>    | <b>9</b> |

## 1 Introduction

The package "ReadqPCR" contains different functions for reading qPCR data into R.

As well as the functions to read in the data, "ReadqPCR" contains the `qPCRBatch` and `CyclesSet` class definition. The data output by these RT-qPCR systems is in the form of fluorescence values or quantification cycle (Cq values), which represents the number of cycles of amplification needed in order to detect the expression of a given gene from a sample.

"ReadqPCR" is designed to be complementary to another R package, "NormqPCR", which is intended for the normalisation of qPCR data. It must be installed before the other module.

We load the "ReadqPCR" package.

```
> library(ReadqPCR)
```

## 2 read.LC480

With function `read.LC480` raw fluorescence data of Roche LightCycler 480 may be read in. The result is saved in an object of class `CyclesSet`. At the moment the function works only with the data exported to a txt-file, but we plan to add support also for the xml-export.

```
> path <- system.file("exData", package = "ReadqPCR")
> LC480.example <- file.path(path, "LC480_Example.txt")
> cycData <- read.LC480(file = LC480.example)
> ## Fluorescence data
> head(exprs(cycData))
```

|   | A1    | A2    | A3    | A4    | A5    | A6    | A7    | A8    | A9    | A10   | A11      | A12   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|-------|
| 1 | 15.58 | 16.93 | 27.32 | 16.60 | 16.88 | 27.93 | 15.37 | 17.27 | 27.26 | 15.91 | 41594.00 | 25.74 |
| 2 | 15.53 | 16.96 | 27.69 | 16.68 | 16.91 | 28.23 | 15.47 | 17.35 | 27.59 | 15.87 | 16.17    | 25.76 |
| 3 | 15.49 | 16.93 | 27.56 | 16.67 | 16.95 | 28.27 | 15.41 | 17.32 | 27.60 | 15.83 | 16.23    | 25.77 |
| 4 | 15.47 | 16.97 | 27.62 | 16.63 | 16.87 | 28.22 | 15.42 | 17.28 | 27.62 | 15.83 | 16.17    | 25.70 |
| 5 | 15.47 | 16.88 | 27.56 | 16.65 | 16.92 | 28.22 | 15.38 | 17.31 | 27.52 | 15.74 | 16.18    | 25.64 |
| 6 | 15.41 | 16.90 | 27.55 | 16.65 | 16.87 | 28.20 | 15.41 | 17.27 | 27.57 | 15.76 | 16.23    | 25.70 |

  

|   | B1    | B2    | B3    | B4    | B5    | B6    | B7    | B8       | B9    | B10      | B11   |
|---|-------|-------|-------|-------|-------|-------|-------|----------|-------|----------|-------|
| 1 | 16.61 | 17.74 | 27.15 | 17.57 | 17.67 | 29.30 | 41322 | 41625.00 | 26.84 | 16.93    | 16.64 |
| 2 | 16.67 | 17.80 | 27.42 | 17.61 | 17.71 | 29.76 | 41322 | 17.19    | 27.58 | 41625.00 | 16.68 |
| 3 | 16.57 | 17.78 | 27.47 | 17.64 | 17.73 | 29.74 | 41322 | 17.16    | 27.58 | 41350.00 | 16.64 |
| 4 | 16.56 | 17.72 | 27.49 | 17.57 | 17.64 | 29.87 | 41442 | 17.22    | 27.61 | 17.14    | 16.57 |
| 5 | 16.52 | 17.68 | 27.44 | 17.59 | 17.62 | 29.78 | 17    | 41625.00 | 27.56 | 41472.00 | 16.57 |
| 6 | 16.59 | 17.69 | 27.50 | 17.54 | 17.62 | 29.90 | 41564 | 17.22    | 27.61 | 17.14    | 16.56 |

  

|   | B12      | C1       | C2    | C3    | C4       | C5    | C6       | C7    | C8       | C9       |
|---|----------|----------|-------|-------|----------|-------|----------|-------|----------|----------|
| 1 | 41512.00 | 41322.00 | 16.60 | 27.13 | 41292.00 | 16.77 | 26.88    | 17.43 | 16.96    | 27.86    |
| 2 | 26.35    | 16.89    | 16.55 | 27.43 | 18.14    | 16.77 | 27.19    | 17.50 | 41442.00 | 28.19    |
| 3 | 26.21    | 16.86    | 16.54 | 27.46 | 41473.00 | 16.81 | 41574.00 | 17.50 | 16.99    | 28.22    |
| 4 | 26.27    | 16.81    | 16.51 | 27.38 | 41504.00 | 16.83 | 27.17    | 17.43 | 41564.00 | 41606.00 |
| 5 | 26.22    | 16.79    | 16.43 | 27.48 | 41443.00 | 16.87 | 27.16    | 17.47 | 41322.00 | 28.15    |
| 6 | 26.15    | 16.84    | 16.44 | 27.47 | 41626.00 | 16.86 | 27.14    | 17.51 | 41291.00 | 28.17    |

  

|   | C10      | C11   | C12      | D1       | D2    | D3    | D4    | D5    | D6    | D7    | D8    |
|---|----------|-------|----------|----------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 41443.00 | 16.49 | 25.92    | 17.22    | 16.80 | 27.25 | 17.66 | 17.18 | 27.41 | 17.42 | 17.22 |
| 2 | 41535.00 | 16.53 | 26.22    | 17.28    | 16.76 | 27.62 | 17.69 | 17.26 | 27.59 | 17.49 | 17.14 |
| 3 | 18.00    | 16.57 | 26.30    | 41564.00 | 16.72 | 27.51 | 17.71 | 17.26 | 27.55 | 17.40 | 17.26 |
| 4 | 41443.00 | 16.55 | 26.24    | 41595.00 | 16.76 | 27.61 | 17.62 | 17.30 | 27.72 | 17.50 | 17.27 |
| 5 | 18.00    | 16.54 | 41390.00 | 41534.00 | 16.72 | 27.45 | 17.73 | 17.27 | 27.66 | 17.49 | 17.27 |
| 6 | 17.98    | 16.49 | 41451.00 | 41291.00 | 16.71 | 27.47 | 17.64 | 17.29 | 27.69 | 17.45 | 17.20 |

  

|   | D9    | D10   | D11   | D12      | E1    | E2    | E3    | E4    | E5    | E6    | E7    |
|---|-------|-------|-------|----------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 27.28 | 17.47 | 16.63 | 41332.00 | 27.52 | 17.80 | 26.51 | 28.69 | 17.62 | 27.48 | 27.64 |

|   |          |          |          |          |          |          |          |          |       |          |          |       |
|---|----------|----------|----------|----------|----------|----------|----------|----------|-------|----------|----------|-------|
| 2 | 27.74    | 17.46    | 16.70    | 27.38    | 27.78    | 17.79    | 26.84    | 29.00    | 17.67 | 27.79    | 28.00    |       |
| 3 | 27.74    | 17.40    | 16.66    | 27.38    | 27.69    | 17.75    | 26.88    | 28.99    | 17.71 | 27.89    | 27.99    |       |
| 4 | 27.91    | 17.51    | 16.76    | 27.42    | 27.61    | 17.71    | 26.90    | 41423.00 | 17.72 | 27.93    | 41361.00 |       |
| 5 | 27.82    | 17.43    | 16.69    | 27.33    | 27.63    | 17.79    | 26.82    | 41393.00 | 17.74 | 27.95    | 41483.00 |       |
| 6 | 27.87    | 17.46    | 16.69    | 27.41    | 27.59    | 17.76    | 26.84    | 41362.00 | 17.77 | 41302.00 | 28.14    |       |
|   | E8       | E9       | E10      | E11      | E12      | F1       | F2       | F3       | F4    | F5       |          |       |
| 1 | 16.97    | 41361.00 | 27.17    | 16.69    | 26.82    | 41605.00 | 41473.00 | 28.28    | 28.24 | 41442.00 |          |       |
| 2 | 41442.00 | 28.53    | 27.41    | 16.88    | 27.20    | 27.25    | 18.15    | 28.65    | 28.65 | 41472.00 |          |       |
| 3 | 41442.00 | 28.51    | 27.33    | 16.83    | 27.19    | 26.99    | 41535.00 | 28.61    | 28.64 | 41381.00 |          |       |
| 4 | 41534.00 | 28.54    | 27.37    | 16.85    | 27.19    | 41544.00 | 18.19    | 28.61    | 28.60 | 17.16    |          |       |
| 5 | 41411.00 | 28.52    | 27.33    | 16.81    | 27.19    | 26.99    | 41412.00 | 28.53    | 28.61 | 17.18    |          |       |
| 6 | 41350.00 | 28.58    | 27.41    | 16.80    | 27.18    | 27.00    | 41412.00 | 28.48    | 28.66 | 17.18    |          |       |
|   | F6       | F7       | F8       | F9       | F10      | F11      | F12      | G1       | G2    | G3       | G4       |       |
| 1 | 27.99    | 27.50    | 16.67    | 27.65    | 41422.00 | 16.68    | 26.61    | 27.91    | 44743 | 15189    | 27.7     |       |
| 2 | 28.29    | 27.79    | 16.74    | 27.95    | 28.39    | 16.83    | 26.97    | 41453.00 | 45108 | 17380    | 41392.0  |       |
| 3 | 28.25    | 27.84    | 16.74    | 27.98    | 28.35    | 16.78    | 26.95    | 27.99    | 46204 | 16285    | 28.0     |       |
| 4 | 28.30    | 27.88    | 16.84    | 41333.00 | 28.38    | 16.82    | 26.99    | 27.89    | 44743 | 15554    | 41453.0  |       |
| 5 | 28.33    | 27.94    | 16.92    | 41392.00 | 28.31    | 16.86    | 26.96    | 27.84    | 44743 | 15554    | 41422.0  |       |
| 6 | 28.28    | 27.95    | 16.82    | 41361.00 | 28.39    | 16.86    | 26.97    | 27.74    | 41456 | 12997    | 41514.0  |       |
|   | G5       | G6       | G7       | G8       | G9       | G10      | G11      | G12      | H1    | H2       | H3       | H4    |
| 1 | 31929    | 22433    | 27.79    | 34121    | 29738    | 28.32    | 20668    | 32295    | 15.97 | 41410.00 | 45108    | 15158 |
| 2 | 33756    | 23894    | 41361.00 | 35582    | 31929    | 28.58    | 24685    | 35582    | 15.85 | 15.97    | 46204    | 17715 |
| 3 | 33025    | 22433    | 41422.00 | 34851    | 30834    | 28.46    | 23590    | 33756    | 15.76 | 15.88    | 46569    | 16984 |
| 4 | 32660    | 24259    | 41514.00 | 35217    | 31199    | 28.42    | 22859    | 34121    | 15.72 | 15.88    | 45474    | 15523 |
| 5 | 33025    | 21702    | 41392.00 | 33756    | 28642    | 28.38    | 20302    | 33025    | 15.75 | 15.84    | 44378    | 16619 |
| 6 | 32660    | 20972    | 27.97    | 32295    | 29738    | 28.41    | 21398    | 33756    | 15.75 | 15.82    | 42552    | 13697 |
|   | H5       | H6       | H7       | H8       | H9       | H10      | H11      | H12      |       |          |          |       |
| 1 | 26.70    | 41391.00 | 14427    | 21002    | 24624    | 24624    | 41371    | 17746    |       |          |          |       |
| 2 | 41391.00 | 27.28    | 18810    | 24289    | 28277    | 26816    | 41554    | 21763    |       |          |          |       |
| 3 | 26.90    | 27.17    | 17349    | 22098    | 25720    | 24259    | 41312    | 19572    |       |          |          |       |
| 4 | 26.85    | 27.21    | 15158    | 21732    | 26816    | 25355    | 41432    | 19572    |       |          |          |       |
| 5 | 26.82    | 27.21    | 14427    | 21002    | 26451    | 23894    | 41312    | 17746    |       |          |          |       |
| 6 | 26.80    | 27.26    | 14793    | 22098    | 25720    | 23163    | 36312    | 15554    |       |          |          |       |

```
> ## Pheno data
> head(pData(cycData))
```

|    | Sample position | Sample name | Program number | Segment number |
|----|-----------------|-------------|----------------|----------------|
| A1 | A1              | Sample_1    | 2              | 3              |
| A2 | A2              | Sample_2    | 2              | 3              |
| A3 | A3              | Sample_2    | 2              | 3              |

|    |    |          |   |   |
|----|----|----------|---|---|
| A4 | A4 | Sample_3 | 2 | 3 |
| A5 | A5 | Sample_4 | 2 | 3 |
| A6 | A6 | Sample_4 | 2 | 3 |

```
> ## Feature data
> head(fData(cycData))
```

|   | Cycle number | Acquisition time | Acquisition temperature |
|---|--------------|------------------|-------------------------|
| 1 | 1            | 691600           | 71.79                   |
| 2 | 2            | 770133           | 71.64                   |
| 3 | 3            | 848716           | 71.64                   |
| 4 | 4            | 927233           | 71.67                   |
| 5 | 5            | 1005816          | 71.67                   |
| 6 | 6            | 1084316          | 71.67                   |

The class `CyclesSet` is an extension of class `eSet`.

```
> cycData
```

```
CyclesSet (storageMode: lockedEnvironment)
assayData: 45 features, 96 samples
  element names: exprs
protocolData: none
phenoData
  sampleNames: A1 A2 ... H12 (96 total)
  varLabels: Sample position Sample name Program number Segment number
  varMetadata: labelDescription
featureData
  featureNames: 1 2 ... 45 (45 total)
  fvarLabels: Cycle number Acquisition time Acquisition temperature
  fvarMetadata: labelDescription
experimentData: use 'experimentData(object)'
Annotation:
```

```
> ## Information about class CyclesSet
> getClass("CyclesSet")
```

```
Class "CyclesSet" [package "ReadqPCR"]
```

```
Slots:
```

|       |           |           |             |
|-------|-----------|-----------|-------------|
| Name: | assayData | phenoData | featureData |
|-------|-----------|-----------|-------------|

Class:            AssayData AnnotatedDataFrame AnnotatedDataFrame

Name:            experimentData            annotation            protocolData

Class:            MIAxE            character AnnotatedDataFrame

Name:    .\_\_classVersion\_\_

Class:            Versions

Extends:

Class "eSet", directly

Class "VersionedBiobase", by class "eSet", distance 2

Class "Versioned", by class "eSet", distance 3

The additional sample information file can be read in with function `read.LC480SampleInfo` and is saved in an object of class `AnnotatedDataFrame`.

```
> LC480.SamInfo <- file.path(path, "LC480_Example_SampleInfo.txt")
> samInfo <- read.LC480SampleInfo(file = LC480.SamInfo)
> ## Additional sample information
> head(pData(samInfo))
```

|   | Sample position | Sample name | Replicate of | Filter combination | Target name       |
|---|-----------------|-------------|--------------|--------------------|-------------------|
| 1 | A1              | Sample_1    |              | 465-510            | negativ Kontrolle |
| 2 | A2              | Sample_2    |              | 465-510            | goi               |
| 3 | A3              | Sample_2    |              | 465-510            | hk                |
| 4 | A4              | Sample_3    |              | 465-510            | negativ Kontrolle |
| 5 | A5              | Sample_4    |              | 465-510            | goi               |
| 6 | A6              | Sample_4    |              | 465-510            | hk                |

  

|   | Sample Pref | color | Efficiency | Combined sample | and target type |
|---|-------------|-------|------------|-----------------|-----------------|
| 1 | \$00FF8000  |       | 2          | Target          | Negative        |
| 2 | clRed       |       | 2          | Target          | Unknown         |
| 3 | \$0030D700  |       | 2          | Ref             | Unknown         |
| 4 | clFuchsia   |       | 2          | Target          | Negative        |
| 5 | clGray      |       | 2          | Target          | Unknown         |
| 6 | \$0012D7FA  |       | 2          | Ref             | Unknown         |

For adding this additional information to the `CyclesSet` we provide a method for function `merge`.

```
> cycData1 <- merge(cycData, samInfo)
> ## Extended pheno data
> phenoData(cycData1)
```

```

An object of class 'AnnotatedDataFrame'
 sampleNames: 1 2 ... 96 (96 total)
 varLabels: Sample position Sample name ... Combined sample and target
            type (10 total)
 varMetadata: labelDescription
> head(pData(cycData1))

  Sample position Sample name Program number Segment number Replicate of
1             A1   Sample_1             2             3
2             A2   Sample_2             2             3
3             A3   Sample_2             2             3
4             A4   Sample_3             2             3
5             A5   Sample_4             2             3
6             A6   Sample_4             2             3
  Filter combination Target name Sample Pref color Efficiency
1      465-510 negativ Kontrolle    $00FF8000             2
2      465-510             goi          clRed             2
3      465-510             hk    $0030D700             2
4      465-510 negativ Kontrolle    clFuchsia             2
5      465-510             goi          clGray             2
6      465-510             hk    $0012D7FA             2
  Combined sample and target type
1      Target Negative
2      Target Unknown
3      Ref Unknown
4      Target Negative
5      Target Unknown
6      Ref Unknown
> varMetadata(phenoData(cycData1))

                                labelDescription
Sample position                Sample position
Sample name                    Sample name
Program number                 Program number
Segment number                 Segment number
Replicate of                   Replicate of
Filter combination              Filter combination
Target name                    Target name
Sample Pref color              Sample Pref color
Efficiency                     Efficiency
Combined sample and target type Combined sample and target type

```

### 3 read.qPCR

`read.qPCR` allows the user to read in qPCR data and populate a `qPCRBatch` R object (see section `qPCRBatch`) using their own data matrix. The format of the data file should be tab delimited and have the following columns, the first two of which are optional (although they should either be provided together, or not at all):

**Well** Optional, this represents the position of the detector on a plate. This information, if given, will be used to check the plates are of the same size and will also be used in order to plot a representation of the card to look for spatial effects and other potential problems. Both Well number and Plate ID must be present to enable a plate to be plotted.

**Plate** Optional, this is an identifier for the plate on which an experiment was performed. It is not possible to have duplicate plate IDs with the same Well number. Neither is it possible to have Plate Ids without Well numbers. Both Well number and Plate ID must be present to enable a plate to be plotted.

**Sample** The sample being analysed. Each sample must contain the same detectors in order to combine and compare samples effectively and to form a valid expression set matrix.

**Detector** This is the identifier for the gene being investigated. The Detectors must be identical for each sample.

**Cq** This is the quantification cycle value for a given detector in the corresponding sample.

The generic function `read.qPCR` is called to read in the qPCR file. It is similar to the `read.affybatch` function of the "affy" package, in that it reads a file and automatically populates an R object, `qPCRBatch` described below. However it is different in that the file is user formatted. In addition, unlike `read.affybatch`, and also unlike the `read.taqman` function detailed below, only one file may be read in at a time.

If **Well** and **Plate ID** information are given, then these are used to populate the `exprs.well.order`, a new `assayData` slot introduced in the `qPCRBatch` object, as detailed below in section `qPCRBatch`.

So for the `qPCR.example.txt` file, in directory `exData` of this library, which contains **Well** and **Plate ID** information, as well as the mandatory **Sample**, **Detector** and **Cq** information, we can read in the data as follows.

```
> path <- system.file("exData", package = "ReadqPCR")
> qPCR.example <- file.path(path, "qPCR.example.txt")
> qPCRBatch.qPCR <- read.qPCR(qPCR.example)
```

`qPCRBatch.qPCR` will be a `qPCRBatch` object with an `exprs` and `exprs.well.order`, as well as a `phenoData` slot which gets automatically populated in the same way as when using `read.affybatch`. More detail is given in the `qPCRBatch` section below.

`read.qPCR` can deal with technical replicates. If the same detector and sample identifier occurs more than once, the suffix `_TechReps.n` is concatenated to the detector name, where  $n$  in  $\{1, 2, \dots, N\}$  is the number of the replication in the total number of replicates,  $N$ , based on order of appearance in the qPCR data file. So for a qPCR file with 2 technical replicates and 8 detectors per replicate, with one replicate per plate, the detector names would be amended as follows:

```
> qPCR.example.techReps <- file.path(path, "qPCR.techReps.txt")
> qPCRBatch.qPCR.techReps <- read.qPCR(qPCR.example.techReps)
> rownames(exprs(qPCRBatch.qPCR.techReps))[1:8]

[1] "gene_aj_TechReps.1" "gene_aj_TechReps.2" "gene_al_TechReps.1"
[4] "gene_al_TechReps.2" "gene_ax_TechReps.1" "gene_ax_TechReps.2"
[7] "gene_bo_TechReps.1" "gene_bo_TechReps.2"
```

The reason for appending the suffix when technical replicates are encountered is in order to populate the `exprs` and `exprs.well.order` slots correctly and keep them to the `assayData` format. It also allows the decisions on how to deal with the analysis and combination of technical replicates to be controlled by the user, either using the "`NormqPCR`" package, or potentially some other function that takes `assayData` format R objects as input.

## 4 read.taqman

`read.taqman` allows the user to read in the data output by the Sequence Detection Systems (SDS) software which is the software used to analyse the Taqman Low Density Arrays. This data consists of the header section, which gives some general information about the experiment, run date etc., followed by the raw Cq values detected by the software, followed by summary data about the experiment. `read.taqman` is a generic function, and is called in a way similar to the `read.affybatch` function of the "`affy`" package.

```
> taqman.example <- file.path(path, "example.txt")
> qPCRBatch.taq <- read.taqman(taqman.example)
```

Currently the SDS software only allows up to 10 plates to be output onto one file. `read.taqman` allows any number of SDS output files to be combined to make a single `qPCRBatch`, as long as they have matching detector identifiers.

```
> path <- system.file("exData", package = "ReadqPCR")
> taqman.example <- file.path(path, "example.txt")
```



```
> taqman.example.second.file <- file.path(path, "example2.txt")
> qPCRBatch.taq.two.files <- read.taqman(taqman.example,
+                                       taqman.example.second.file)
```

SDS output will not necessarily contain plate identifiers, in which case a numeric identifier will be generated, which will increment for each plate, depending on the order of the plates within the SDS files. This is important for filling the `exprs.well.order` slot of the `qPCRBatch`.

`read.taqman` can also deal with technical replicates. If the same detector and sample identifier occurs more than once, the suffix `_TechRep.n` will be concatenated to the detector name, where  $n$  in  $\{1, 2, \dots, N\}$  is the number of the replication in the total number of replicates  $N$ , based on the order of occurrence in the taqman data file. So for a taqman file with 4 technical replicates of 96 detectors per sample, with one sample per plate, the detector names would be amended as follows:

```
> taqman.example.tech.reps <- file.path(path, "exampleTechReps.txt")
> qPCRBatch.taq.tech.reps <- read.taqman(taqman.example.tech.reps)
> rownames(exprs(qPCRBatch.taq.tech.reps))[1:8]
```

```
[1] "ACE.Hs00174179_m1_TechReps.1"
[2] "ACE.Hs00174179_m1_TechReps.2"
[3] "ACE.Hs00174179_m1_TechReps.3"
[4] "ACE.Hs00174179_m1_TechReps.4"
[5] "AT1R.AGTR1..Hs00241341_m1_TechReps.1"
[6] "AT1R.AGTR1..Hs00241341_m1_TechReps.2"
[7] "AT1R.AGTR1..Hs00241341_m1_TechReps.3"
[8] "AT1R.AGTR1..Hs00241341_m1_TechReps.4"
```

As with `read.qPCR`, the motivation for appending the suffix when technical replicates are encountered is in order to populate the `exprs` and `exprs.well.order` slots correctly and keep them to the `assayData` format. Again it allows the decisions on how to deal with the analysis of technical replicates to be controlled by the user, either using the "NormqPCR" package, or otherwise.

## 5 qPCRBatch

`qPCRBatch` is an S4 class, designed to store information on the raw Cq values which represents the relative gene expression for a given sample, phenotypic information on the different samples which enable the user to compare expression accross different conditions or cell lines, and information on the spatial location of the different detectors used to measure Cq. This is achieved by making `qPCRBatch` an an extension of `eSet`, which means we

can recycle slots such as `exprs` and `pData`, and by introducing a new `assayData` slot. Here is an example of what a `qPCRBatch` looks like. note the similarity to `eSet`:

```
> qPCRBatch.taq

qPCRBatch (storageMode: lockedEnvironment)
assayData: 96 features, 8 samples
  element names: exprs, exprs.well.order
protocolData: none
phenoData
  sampleNames: fp1.day3.v fp2.day3.v ... fp.8.day.3.mia (8 total)
  varLabels: sample
  varMetadata: labelDescription
featureData: none
experimentData: use 'experimentData(object)'
Annotation:
```

`pData` will be filled automatically if no data is given, in a way analagous to `read.affybatch`:

```
> pData(qPCRBatch.taq)
```

|                | sample |
|----------------|--------|
| fp1.day3.v     | 1      |
| fp2.day3.v     | 2      |
| fp5.day3.mia   | 3      |
| fp6.day3.mia   | 4      |
| fp.3.day.3.v   | 5      |
| fp.4.day.3.v   | 6      |
| fp.7.day.3.mia | 7      |
| fp.8.day.3.mia | 8      |

In addition there is a new slot, `exprs.well.order` which extends the `assayData` slot used for `exprs()`. It has the same dimensions as `exprs` (as every instance of `assayData` must). The cells contain further details on the position on the arrays where the different measurements were taken.

The data provided by this slot can be used in order to identify certain problems with arrays, perhaps due to spatial effects and other problems with the microfluidics technology that is used by many of these systems.

This is conceptually similar to the `cdf` file information being stored in the `AffyBatch` class, which contains information on the spatial layout of features on an affy chip. However it differs since it allows for different arrays within the same `affyBatch` object to have different

layouts to each other. This information can be viewed using the `exprs.well.order()` function.

When using `read.taqman`, if the input file includes identifiers for the different arrays in the experiment, the identifiers will be of the format `<plate.id>-<plate.position>`. However if no names are given for the different plates, "ReadqPCR" will assign them a numeric identifier, which increments depending on the order of plates in the original file. When several input files are given, as in the case of SDS files, the order in which they are supplied as arguments to the `read.taqman` function will be mirrored in the order of the numeric identifiers for the different plates. However, to minimise confusion, we recommend the useR giving the plates their own unique identifiers where possible.

Without plate names:

```
> head(exprs.well.order(qPCRBatch.taq))
```

|                      | fp1.day3.v | fp2.day3.v | fp5.day3.mia | fp6.day3.mia |
|----------------------|------------|------------|--------------|--------------|
| Actb.Rn00667869_m1   | "1-38"     | "1-134"    | "1-230"      | "1-326"      |
| Adipoq.Rn00595250_m1 | "1-61"     | "1-157"    | "1-253"      | "1-349"      |
| Adrbk1.Rn00562822_m1 | "1-66"     | "1-162"    | "1-258"      | "1-354"      |
| Agtrl1.Rn00580252_s1 | "1-91"     | "1-187"    | "1-283"      | "1-379"      |
| Alpl.Rn00564931_m1   | "1-10"     | "1-106"    | "1-202"      | "1-298"      |
| B2m.Rn00560865_m1    | "1-37"     | "1-133"    | "1-229"      | "1-325"      |

  

|                      | fp.3.day.3.v | fp.4.day.3.v | fp.7.day.3.mia | fp.8.day.3.mia |
|----------------------|--------------|--------------|----------------|----------------|
| Actb.Rn00667869_m1   | "2-38"       | "2-134"      | "2-230"        | "2-326"        |
| Adipoq.Rn00595250_m1 | "2-61"       | "2-157"      | "2-253"        | "2-349"        |
| Adrbk1.Rn00562822_m1 | "2-66"       | "2-162"      | "2-258"        | "2-354"        |
| Agtrl1.Rn00580252_s1 | "2-91"       | "2-187"      | "2-283"        | "2-379"        |
| Alpl.Rn00564931_m1   | "2-10"       | "2-106"      | "2-202"        | "2-298"        |
| B2m.Rn00560865_m1    | "2-37"       | "2-133"      | "2-229"        | "2-325"        |

With plate names:

```
> taqman.example.plateNames <- file.path(path, "exampleWithPlateNames.txt")
> qPCRBatch.taq.plateNames <- read.taqman(taqman.example.plateNames)
> head(exprs.well.order(qPCRBatch.taq.plateNames))
```

|                      | gp.1.day.3.v | gp.2.day.3.v | gp.5.day.3.mia | gp.6.day.3.mia |
|----------------------|--------------|--------------|----------------|----------------|
| Actb.Rn00667869_m1   | "PlateA-38"  | "PlateA-134" | "PlateA-230"   | "PlateA-326"   |
| Adipoq.Rn00595250_m1 | "PlateA-61"  | "PlateA-157" | "PlateA-253"   | "PlateA-349"   |
| Adrbk1.Rn00562822_m1 | "PlateA-66"  | "PlateA-162" | "PlateA-258"   | "PlateA-354"   |
| Agtrl1.Rn00580252_s1 | "PlateA-91"  | "PlateA-187" | "PlateA-283"   | "PlateA-379"   |
| Alpl.Rn00564931_m1   | "PlateA-10"  | "PlateA-106" | "PlateA-202"   | "PlateA-298"   |
| B2m.Rn00560865_m1    | "PlateA-37"  | "PlateA-133" | "PlateA-229"   | "PlateA-325"   |

|                      | gp.3.day.3.v | gp.4.day.3.v | gp.7.day.3.mia | gp.8.day.3.mia |
|----------------------|--------------|--------------|----------------|----------------|
| Actb.Rn00667869_m1   | "PlateB-38"  | "PlateB-134" | "PlateB-230"   | "PlateB-326"   |
| Adipoq.Rn00595250_m1 | "PlateB-61"  | "PlateB-157" | "PlateB-253"   | "PlateB-349"   |
| Adrbk1.Rn00562822_m1 | "PlateB-66"  | "PlateB-162" | "PlateB-258"   | "PlateB-354"   |
| Agtrl1.Rn00580252_s1 | "PlateB-91"  | "PlateB-187" | "PlateB-283"   | "PlateB-379"   |
| Alpl.Rn00564931_m1   | "PlateB-10"  | "PlateB-106" | "PlateB-202"   | "PlateB-298"   |
| B2m.Rn00560865_m1    | "PlateB-37"  | "PlateB-133" | "PlateB-229"   | "PlateB-325"   |

In addition, a mixture of files with and without plate identifiers is possible.

```
> taqman.example <- file.path(path, "example.txt")
> taqman.example.plateNames <- file.path(path, "exampleWithPlateNames.txt")
> qPCRBatch.taq.mixedPlateNames <- read.taqman(taqman.example,
+                                             taqman.example.plateNames)
> head(exprs.well.order(qPCRBatch.taq.mixedPlateNames))
```

|                      | fp1.day3.v | fp2.day3.v | fp5.day3.mia | fp6.day3.mia |
|----------------------|------------|------------|--------------|--------------|
| Actb.Rn00667869_m1   | "1-38"     | "1-134"    | "1-230"      | "1-326"      |
| Adipoq.Rn00595250_m1 | "1-61"     | "1-157"    | "1-253"      | "1-349"      |
| Adrbk1.Rn00562822_m1 | "1-66"     | "1-162"    | "1-258"      | "1-354"      |
| Agtrl1.Rn00580252_s1 | "1-91"     | "1-187"    | "1-283"      | "1-379"      |
| Alpl.Rn00564931_m1   | "1-10"     | "1-106"    | "1-202"      | "1-298"      |
| B2m.Rn00560865_m1    | "1-37"     | "1-133"    | "1-229"      | "1-325"      |

  

|                      | fp.3.day.3.v | fp.4.day.3.v | fp.7.day.3.mia | fp.8.day.3.mia |
|----------------------|--------------|--------------|----------------|----------------|
| Actb.Rn00667869_m1   | "2-38"       | "2-134"      | "2-230"        | "2-326"        |
| Adipoq.Rn00595250_m1 | "2-61"       | "2-157"      | "2-253"        | "2-349"        |
| Adrbk1.Rn00562822_m1 | "2-66"       | "2-162"      | "2-258"        | "2-354"        |
| Agtrl1.Rn00580252_s1 | "2-91"       | "2-187"      | "2-283"        | "2-379"        |
| Alpl.Rn00564931_m1   | "2-10"       | "2-106"      | "2-202"        | "2-298"        |
| B2m.Rn00560865_m1    | "2-37"       | "2-133"      | "2-229"        | "2-325"        |

  

|                      | gp.1.day.3.v | gp.2.day.3.v | gp.5.day.3.mia | gp.6.day.3.mia |
|----------------------|--------------|--------------|----------------|----------------|
| Actb.Rn00667869_m1   | "PlateA-38"  | "PlateA-134" | "PlateA-230"   | "PlateA-326"   |
| Adipoq.Rn00595250_m1 | "PlateA-61"  | "PlateA-157" | "PlateA-253"   | "PlateA-349"   |
| Adrbk1.Rn00562822_m1 | "PlateA-66"  | "PlateA-162" | "PlateA-258"   | "PlateA-354"   |
| Agtrl1.Rn00580252_s1 | "PlateA-91"  | "PlateA-187" | "PlateA-283"   | "PlateA-379"   |
| Alpl.Rn00564931_m1   | "PlateA-10"  | "PlateA-106" | "PlateA-202"   | "PlateA-298"   |
| B2m.Rn00560865_m1    | "PlateA-37"  | "PlateA-133" | "PlateA-229"   | "PlateA-325"   |

  

|                      | gp.3.day.3.v | gp.4.day.3.v | gp.7.day.3.mia | gp.8.day.3.mia |
|----------------------|--------------|--------------|----------------|----------------|
| Actb.Rn00667869_m1   | "PlateB-38"  | "PlateB-134" | "PlateB-230"   | "PlateB-326"   |
| Adipoq.Rn00595250_m1 | "PlateB-61"  | "PlateB-157" | "PlateB-253"   | "PlateB-349"   |
| Adrbk1.Rn00562822_m1 | "PlateB-66"  | "PlateB-162" | "PlateB-258"   | "PlateB-354"   |
| Agtrl1.Rn00580252_s1 | "PlateB-91"  | "PlateB-187" | "PlateB-283"   | "PlateB-379"   |

```
Alp1.Rn00564931_m1    "PlateB-10"  "PlateB-106" "PlateB-202"  "PlateB-298"
B2m.Rn00560865_m1    "PlateB-37"  "PlateB-133" "PlateB-229"  "PlateB-325"
```

If the files to be combined do not have matching detector names, or if duplicate sample or plate names are given, `read.taqman` will stop and give an error message.

When reading in `qPCR` files with `read.qPCR`, `exprs.well.order` will be populated as long as `Well` and `Plate ID` columns are given in the input file, otherwise the `exprs.well.order` slot will be `NULL`.

So when plate ID and Well data are given:

```
> head(exprs.well.order(qPCRBatch.qPCR))
```

|                    | caseA | caseB | controlA | controlB |
|--------------------|-------|-------|----------|----------|
| gene_ai_TechReps.1 | A-18  | A-43  | B-18     | B-43     |
| gene_ai_TechReps.2 | C-18  | C-43  | D-18     | D-43     |
| gene_az_TechReps.1 | A-23  | A-48  | B-23     | B-48     |
| gene_az_TechReps.2 | C-23  | C-48  | D-23     | D-48     |
| gene_bc_TechReps.1 | A-6   | A-31  | B-6      | B-31     |
| gene_bc_TechReps.2 | C-6   | C-31  | D-6      | D-31     |

And when they are not:

```
> qPCR.example.noPlateOrWell <- file.path(path, "qPCR.noPlateOrWell.txt")
> qPCRBatch.qPCR.noPlateOrWell <- read.qPCR(qPCR.example.noPlateOrWell)
> exprs.well.order(qPCRBatch.qPCR.noPlateOrWell)
```

`NULL`

Once a `qPCRBatch` has been populated it is theoretically possible to use any tool which takes as it's input an `exprs` set matrix. However it is important to bear in mind the values are not raw expression values but `Cq` values, and a lower `Cq` will indicate a higher expression level for a given transcript in the sample. Also it is important to note that when normalising, the amount is relative and is intended to be compared to another condition or tissue type in order to look for differential expression between condition; the technology is not designed to give absolute quantification.