

Tutorial: ggplot2

About the ggplot2 Package

Introduction

"ggplot2 is an R package for producing statistical, or data, graphics, but it is unlike most other graphics packages because it has a deep underlying grammar. This grammar, based on the Grammar of Graphics (Wilkinson, 2005), is composed of a set of independent components that can be composed in many different ways. [...] Plots can be built up iteratively and edited later. A carefully chosen set of defaults means that most of the time you can produce a publication-quality graphic in seconds, but if you do have special formatting requirements, a comprehensive theming system makes it easy to do what you want. [...]"

ggplot2 is designed to work in a layered fashion, starting with a layer showing the raw data then adding layers of annotation and statistical summaries. [...]"

H. Wickham, ggplot2, Use R, DOI 10.1007/978-0-387-98141_1, © Springer Science+Business Media, LLC 2009

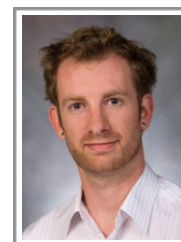
"ggplot2 is a plotting system for R, based on the grammar of graphics, which tries to take the good parts of base and lattice graphics and none of the bad parts. It takes care of many of the fiddly details that make plotting a hassle (like drawing legends) as well as providing a powerful model of graphics that makes it easy to produce complex multi-layered graphics."

<http://had.co.nz/ggplot2>, Dec 2010

Author

ggplot2 was developed by Hadley Wickham, assistant professor of statistics at Rice University, Houston. In July 2010 the latest stable release (Version 0.8.8) was published.

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2004 M.Sc. (Statistics), First Class Honours, The University of Auckland, Auckland, New Zealand.

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Tutorial

Sample code for the illustration of ggplot2

Ramon Saccilotto, 2010-12-08

install & load ggplot library

```
install.packages("ggplot2")
library("ggplot2")
```

show info about the data

```
head(diamonds)
head(mtcars)
```

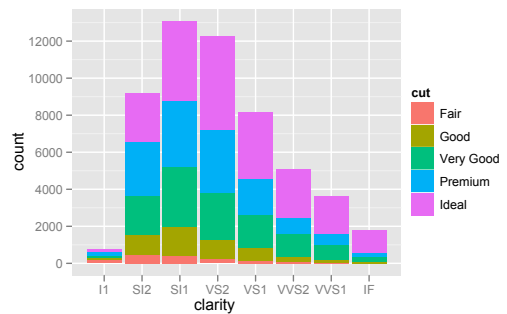
comparison qplot vs ggplot

```
# qplot histogram
```

```
qplot(clarity, data=diamonds, fill=cut, geom="bar")
```

```
# ggplot histogram -> same output
```

```
ggplot(diamonds, aes(clarity, fill=cut)) + geom_bar()
```



how to use qplot

```
# scatterplot
```

```
qplot(wt, mpg, data=mtcars)
```

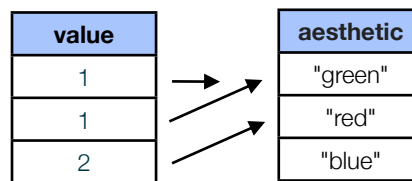
qplot accepts transformed input data

```
# transform input data with functions
```

```
qplot(log(wt), mpg - 10, data=mtcars)
```

```
# add aesthetic mapping (hint: how does mapping work)
```

```
qplot(wt, mpg, data=mtcars, color=qsec)
```



```
# change size of points (hint: color/colour, hint: set aesthetic/mapping)
```

```
qplot(wt, mpg, data=mtcars, color=qsec, size=3)
```

```
qplot(wt, mpg, data=mtcars, colour=qsec, size=l(3))
```

aesthetics can be set to a constant value instead of mapping

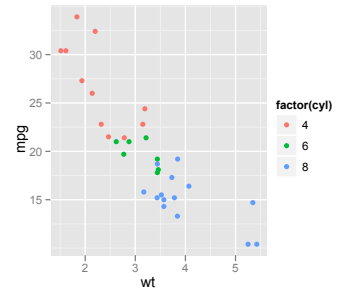
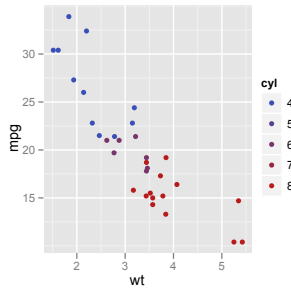
```
# use alpha blending
```

```
qplot(wt, mpg, data=mtcars, alpha=qsec)
```

values between 0 (transparent) and 1 (opaque)

continuous scale vs. discrete scale

```
head(mtcars)
qplot(wt, mpg, data=mtcars, colour=cyl)
levels(mtcars$cyl)
qplot(wt, mpg, data=mtcars, colour=factor(cyl))
```

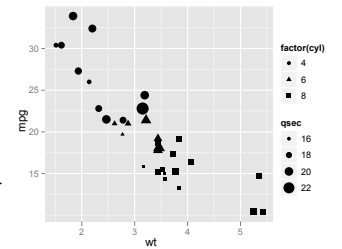


use different aesthetic mappings

```
qplot(wt, mpg, data=mtcars, shape=factor(cyl))
qplot(wt, mpg, data=mtcars, size=qsec)
```

combine mappings (hint: hollow points, geom-concept, legend combination)

```
qplot(wt, mpg, data=mtcars, size=qsec, color=factor(carb))
qplot(wt, mpg, data=mtcars, size=qsec, color=factor(carb), shape=l(1))
qplot(wt, mpg, data=mtcars, size=qsec, shape=factor(cyl), geom="point")
qplot(wt, mpg, data=mtcars, size=factor(cyl), geom="point")
```



legends are combined if possible

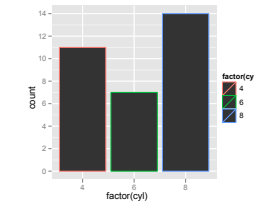
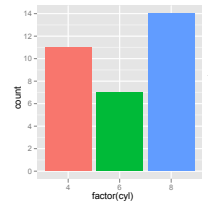
bar-plot

```
qplot(factor(cyl), data=mtcars, geom="bar")
```

flips the plot after calculation of any summary statistics

flip plot by 90°

```
qplot(factor(cyl), data=mtcars, geom="bar") + coord_flip()
```



difference between fill/color bars

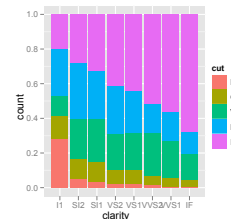
```
qplot(factor(cyl), data=mtcars, geom="bar", fill=factor(cyl))
qplot(factor(cyl), data=mtcars, geom="bar", colour=factor(cyl))
```

fill by variable

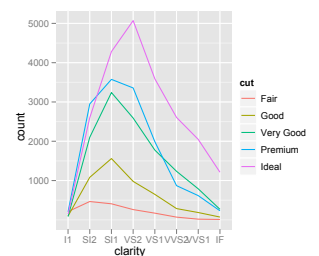
```
qplot(factor(cyl), data=mtcars, geom="bar", fill=factor(gear))
```

use different display of bars (stacked, dodged, identity)

```
head(diamonds)
qplot(clarity, data=diamonds, geom="bar", fill=cut, position="stack")
qplot(clarity, data=diamonds, geom="bar", fill=cut, position="dodge")
qplot(clarity, data=diamonds, geom="bar", fill=cut, position="fill")
qplot(clarity, data=diamonds, geom="bar", fill=cut, position="identity")
```



```
qplot(clarity, data=diamonds, geom="freqpoly", group=cut, colour=cut, position="identity")
qplot(clarity, data=diamonds, geom="freqpoly", group=cut, colour=cut, position="stack")
```

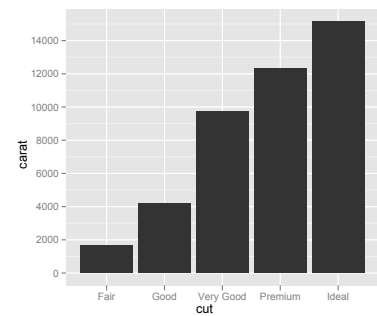


using pre-calculated tables or weights (hint: usage of ddply in package plyr)

```
table(diamonds$cut)
t.table <- ddply(diamonds, c("clarity", "cut"), "nrow")
head(t.table)
```

```
qplot(cut, nrow, data=t.table, geom="bar")
qplot(cut, nrow, data=t.table, geom="bar", stat="identity")
qplot(cut, nrow, data=t.table, geom="bar", stat="identity", fill=clarity)

qplot(cut, data=diamonds, geom="bar", weight=carat)
qplot(cut, data=diamonds, geom="bar", weight=carat, ylab="carat")
```



excursion ddply (split data.frame in subframes and apply functions)

```
ddply(diamonds, "cut", "nrow")
ddply(diamonds, c("cut", "clarity"), "nrow")
ddply(diamonds, "cut", mean)
ddply(diamonds, "cut", summarise, meanDepth = mean(depth))
ddply(diamonds, "cut", summarise, lower = quantile(depth, 0.25, na.rm=TRUE), median = median(depth, na.rm=TRUE), upper = quantile(depth, 0.75, na.rm=TRUE))
```

```
t.function <- function(x,y){
  z = sum(x) / sum(x+y)
  return(z)
}
```

```
ddply(diamonds, "cut", summarise, custom = t.function(depth, price))
ddply(diamonds, "cut", summarise, custom = sum(depth) / sum(depth + price))
```

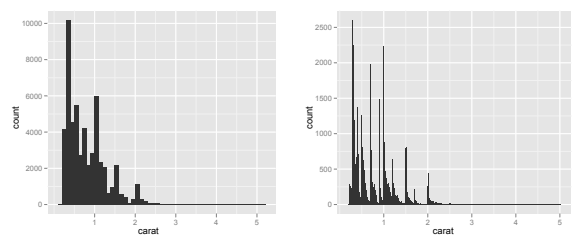
back to ggplot

histogram

```
qplot(carat, data=diamonds, geom="histogram")
```

change binwidth

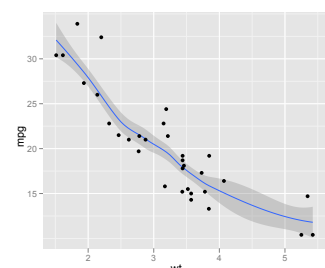
```
qplot(carat, data=diamonds, geom="histogram", binwidth=0.1)
qplot(carat, data=diamonds, geom="histogram", binwidth=0.01)
```



different binwidth changes the picture

use geom to combine plots (hint: order of layers)

```
qplot(wt, mpg, data=mtcars, geom=c("point", "smooth"))
qplot(wt, mpg, data=mtcars, geom=c("smooth", "point"))
qplot(wt, mpg, data=mtcars, color=factor(cyl), geom=c("point", "smooth"))
```



tweaking the smooth plot ("loess"-method: polynomial surface using local fitting)

```
qplot(wt, mpg, data=mtcars, geom=c("point", "smooth"))
```

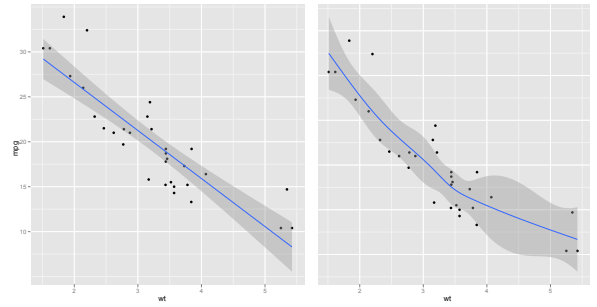
removing standard error

```
qplot(wt, mpg, data=mtcars, geom=c("point", "smooth"), se=FALSE)
```

making line more or less wiggly (span: 0-1)

```
qplot(wt, mpg, data=mtcars, geom=c("point", "smooth"), span=0.6)
```

```
qplot(wt, mpg, data=mtcars, geom=c("point", "smooth"), span=1)
```



using linear modelling

```
qplot(wt, mpg, data=mtcars, geom=c("point", "smooth"), method="lm")
```

using a custom formula for fitting

library(splines)

```
qplot(wt, mpg, data=mtcars, geom=c("point", "smooth"), method="lm", formula = y ~ ns(x,5))
```

illustrate flip versus changing of variable allocation

```
qplot(mpg, wt, data=mtcars, facets=cyl~., geom=c("point", "smooth"))
```

```
qplot(mpg, wt, data=mtcars, facets=cyl~., geom=c("point", "smooth")) + coord_flip()
```

```
qplot(wt, mpg, data=mtcars, facets=cyl~., geom=c("point", "smooth"))
```

flips the plot after calculation of any summary statistics

save plot in variable (hint: data is saved in plot, changes in data do not change plot-data)

```
p.tmp <- qplot(factor(cyl), wt, data=mtcars, geom="boxplot")
```

```
p.tmp
```

save mtcars in tmp-var

```
t.mtcars <- mtcars
```

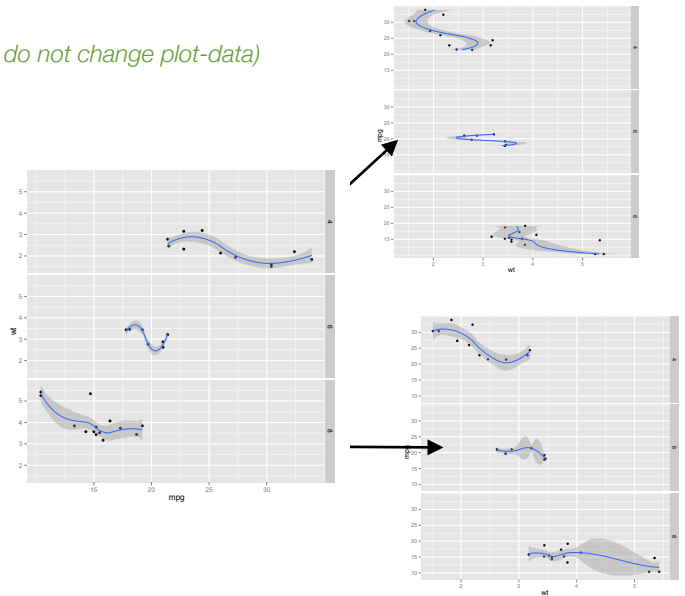
change mtcars

```
mtcars <- transform(mtcars, wt=wt^2)
```

draw plot without/with update of plot data

```
p.tmp
```

```
p.tmp %+% mtcars
```



reset mtcars

```
mtcars <- t.mtcars
```

```
rm(t.mtcars)
```

get information about plot

```
summary(p.tmp)
```

save plot (with data included)

```
> summary(p.tmp)
data: mpg, cyl, disp, hp, drat, wt, qsec, vs, am,
gear, carb [32x11]
mapping: x = factor(cyl), y = wt
faceting: facet_grid(. ~ ., FALSE)
-----
geom_boxplot:
stat_boxplot:
position_dodge: (width = NULL, height = NULL)
```

```
save(p.tmp, file="temp.rData")
```

```
# save image of plot on disk (hint: svg device must be installed)
```

```
ggsave(file="test.pdf")
```

```
ggsave(file="test.jpeg", dpi=72)
```

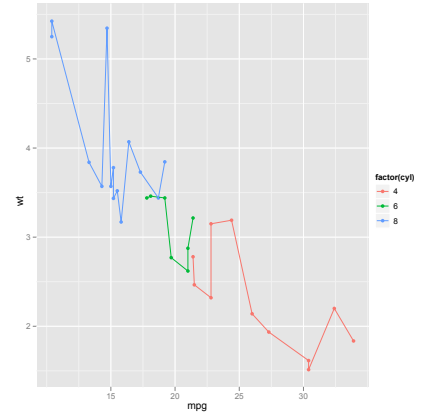
```
ggsave(file="test.svg", plot=p.tmp, width=10, height=5)
```

going further with ggplot

```
# create basic plot (hint: can not be displayed, no layers yet)
```

```
p.tmp <- ggplot(mtcars, aes(mpg, wt, colour=factor(cyl)))
```

```
p.tmp
```



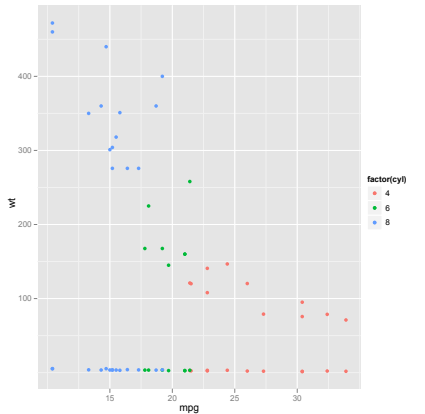
```
# using additional layers (hint: ggplot draws in layers)
```

```
p.tmp + layer(geom="point")
```

```
p.tmp + layer(geom="point") + layer(geom="line")
```

```
# using shortcuts -> geom_XXX(mapping, data, ..., geom, position)
```

```
p.tmp + geom_point()
```



```
# using ggplot-syntax with qplot (hint: qplot creates layers automatically)
```

```
qplot(mpg, wt, data=mtcars, color=factor(cyl), geom="point") + geom_line()
```

```
qplot(mpg, wt, data=mtcars, color=factor(cyl), geom=c("point", "line"))
```

```
# add an additional layer with different mapping
```

```
p.tmp + geom_point()
```

```
p.tmp + geom_point() + geom_point(aes(y=disp))
```

```
# setting aesthetics instead of mapping
```

```
p.tmp + geom_point(color="darkblue")
```

```
p.tmp + geom_point(aes(color="darkblue"))
```

```
# dealing with overplotting (hollow points, pixel points, alpha[0-1])
```

```
t.df <- data.frame(x=rnorm(2000), y=rnorm(2000))
```

```
p.norm <- ggplot(t.df, aes(x,y))
```

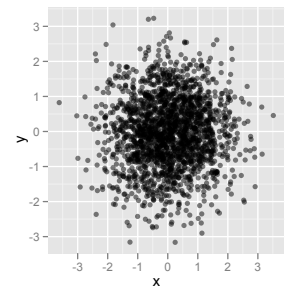
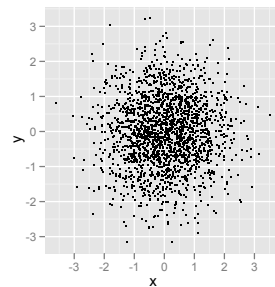
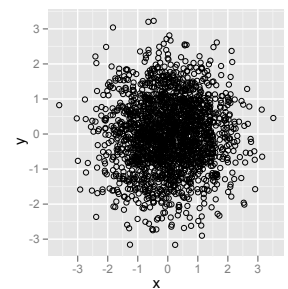
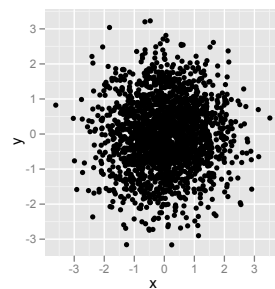
```
p.norm + geom_point()
```

```
p.norm + geom_point(shape=1)
```

```
p.norm + geom_point(shape=".")
```

```
p.norm + geom_point(colour=alpha("black", 1/2))
```

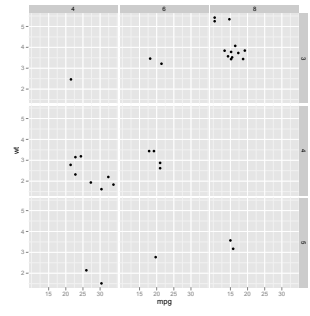
```
p.norm + geom_point(colour=alpha("blue", 1/10))
```



using facets (hint: bug in margins -> doesn't work)

qplot(mpg, wt, data=mtcars, **facets=~cyl**, geom="point")

qplot(mpg, wt, data=mtcars, **facets=gear~cyl**, geom="point")



facet_wrap / facet_grid

qplot(mpg, wt, data=mtcars, **facets=~cyl**, geom="point")

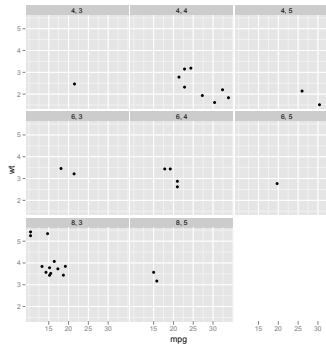
p.tmp <- ggplot(mtcars, aes(mpg, wt)) + geom_point()

p.tmp + **facet_wrap(~cyl)**

p.tmp + **facet_wrap(~cyl, ncol=3)**

p.tmp + **facet_grid(gear~cyl)**

p.tmp + **facet_wrap(~cyl+gear)**

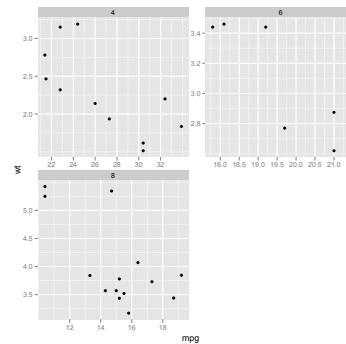


controlling scales in facets (default: scales="fixed")

p.tmp + **facet_wrap(~cyl, scales="free")**

p.tmp + **facet_wrap(~cyl, scales="free_x")**

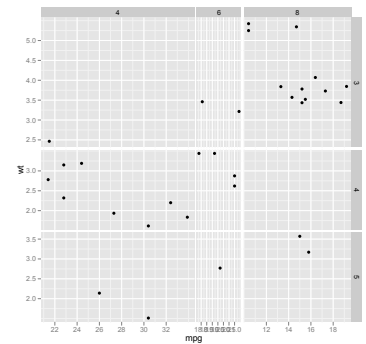
p.tmp + **facet_wrap(~cyl, scales="fixed")**



constraint on facet_grid (all rows, columns same scale)

p.tmp + **facet_grid(gear~cyl, scales="free_x")**

p.tmp + **facet_grid(gear~cyl, scales="free", space="free")**



using scales (color palettes, manual colors, matching of colors to values)

p.tmp <- qplot(cut, data=diamonds, geom="bar", fill=cut)

p.tmp

p.tmp + **scale_fill_brewer()**

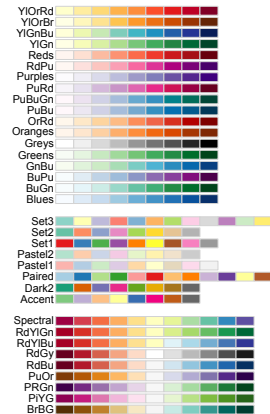
p.tmp + scale_fill_brewer(**palette="Paired"**)

RColorBrewer::display.brewer.all()

p.tmp + **scale_fill_manual(values=c("#7fc6bc", "#083642", "#b1df01", "#cdef9c", "#466b5d"))**

p.tmp + **scale_fill_manual("Color-Matching", c("Fair"="#78ac07", "Good"="#5b99d4",**

"Ideal"="#ff9900", "Very Good"="#5d6778", "Premium"="#da0027", "Not used"="#452354"))



changing text (directly in qplot / additional shortcut)

qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point", **xlab="Descr. of x-axis", ylab="Descr. of y-axis", main="Our Sample Plot"**)

qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") + **xlab("x-axis")**

changing name of legend (bug: in labs you must use "colour", "color" doesn't work)

qplot(mpg, wt, data=mtcars, **colour=factor(cyl)**, geom="point") + **labs(colour="Legend-Name")**

removing legend

qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") + **scale_color_discrete(legend=FALSE)**

qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") + **opts(legend.position="none")**

moving legend to another place

```
qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") + opts(legend.position="left")
```

changing labels on legend

```
qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") +  
scale_colour_discrete(name="Legend for cyl", breaks=c("4", "6", "8"), labels=c("four", "six", "eight"))
```

reordering breaks (values of legend)

```
qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") +  
scale_colour_discrete(name="Legend for cyl", breaks=c("8", "4", "6"))
```

dropping factors

```
mtcars2 <- transform(mtcars, cyl=factor(cyl))  
levels(mtcars2$cyl)  
qplot(mpg, wt, data=mtcars2, colour=cyl, geom="point") + scale_colour_discrete(limits=c("4", "8"))
```

limits vs zooming in vs breaks

```
p.tmp <- qplot(wt, mpg, data=mtcars, geom=c("point",  
"smooth"), method="lm")
```

```
p.tmp
```

```
p.tmp + scale_x_continuous(limits=c(15,30))
```

```
p.tmp + coord_cartesian(xlim=c(15,30))
```

```
p.tmp
```

```
p.tmp + scale_x_continuous(breaks=c(15, 18, 27))
```

```
p.tmp + scale_x_continuous(breaks=c(15, 18, 27),  
labels=c("low", "middle", "high"))
```

using transformation

```
qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point")  
qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") +  
scale_y_continuous(trans="log2")  
qplot(mpg, wt, data=mtcars, colour=factor(cyl), geom="point") +  
scale_y_continuous(trans="log2") + scale_x_log10()
```

themes

use theme for plot only

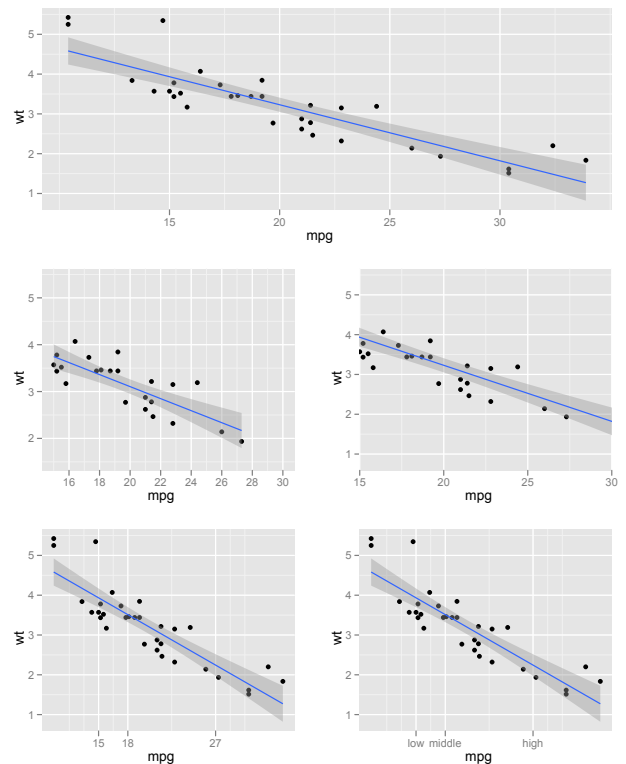
```
qplot(mpg, wt, data=mtcars, geom="point")  
qplot(mpg, wt, data=mtcars, geom="point") + theme_bw()
```

change font-size for all labels (change base_size)

```
qplot(mpg, wt, data=mtcars, geom="point") + theme_bw(18)
```

change theme for all future plots

```
theme_set(theme_bw())
```



get current theme

theme_get()

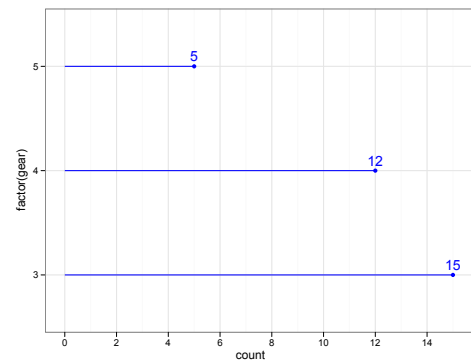
change specific options (hint: "color" does not work in theme_text() -> use colour)

```
qplot(mpg, wt, data=mtcars, geom="point", main="THIS IS A TEST-PLOT")
qplot(mpg, wt, data=mtcars, geom="point", main="THIS IS A TEST-PLOT") + opts(axis.line=theme_segment(),
plot.title=theme_text(size=20, face="bold", colour="steelblue"), panel.grid.minor=theme_blank(),
panel.background=theme_blank(), panel.grid.major=theme_line(linetype="dotted", colour="lightgrey", size=0.5),
panel.grid.major=theme_blank())
```

create barplot like lattice

use combination of geoms and specific stat for bin calculation

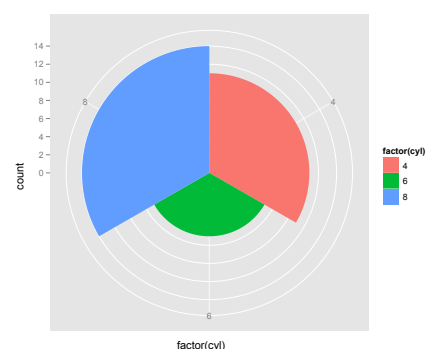
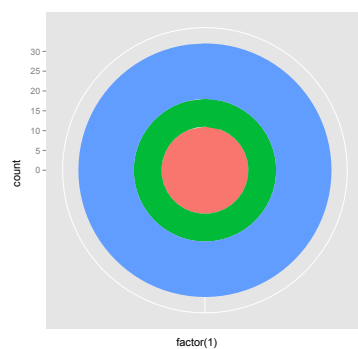
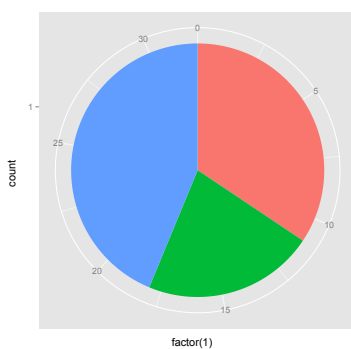
```
qplot(x=factor(gear), ymax=..count.., ymin=0, ymax=..count.., label=..count..,
data=mtcars, geom=c("pointrange", "text"), stat="bin", vjust=-0.5,
color=("blue")) + coord_flip() + theme_bw()
```



create a pie-chart, radar-chart (hint: not recommended)

map a barchart to a polar coordinate system

```
p.tmp <- ggplot(mtcars, aes(x=factor(1), fill=factor(cyl))) + geom_bar(width=1)
p.tmp
p.tmp + coord_polar(theta="y")
p.tmp + coord_polar()
ggplot(mtcars, aes(factor(cyl), fill=factor(cyl))) + geom_bar(width=1) + coord_polar()
```



create survival/cumulative incidence plot

```
library(survival)
```

```
head(lung)
```

```
# create a kaplan-meier plot with survival package
```

```
t.Surv <- Surv(lung$time, lung$status)
```

```
t.survfit <- survfit(t.Surv~1, data=lung)
```

```
plot(t.survfit, mark.time=TRUE)
```

```
# define custom function to create a survival data.frame
```

```
createSurvivalFrame <- function(f.survfit){
```

```
  # initialise frame variable
```

```
  f.frame <- NULL
```

```
  # check if more than one strata
```

```
  if(length(names(f.survfit$strata)) == 0){
```

```
    # create data.frame with data from survfit
```

```
    f.frame <- data.frame(time=f.survfit$time, n.risk=f.survfit$n.risk, n.event=f.survfit$n.event, n.censor = f.survfit
      $n.censor, surv=f.survfit$surv, upper=f.survfit$upper, lower=f.survfit$lower)
```

```
    # create first two rows (start at 1)
```

```
    f.start <- data.frame(time=c(0, f.frame$time[1]), n.risk=c(f.survfit$n, f.survfit$n), n.event=c(0,0),
      n.censor=c(0,0), surv=c(1,1), upper=c(1,1), lower=c(1,1))
```

```
    # add first row to dataset
```

```
    f.frame <- rbind(f.start, f.frame)
```

```
    # remove temporary data
```

```
    rm(f.start)
```

```
  }
```

```
  else {
```

```
    # create vector for strata identification
```

```
    f.strata <- NULL
```

```
    for(f.i in 1:length(f.survfit$strata)){
```

```
      # add vector for one strata according to number of rows of strata
```

```
      f.strata <- c(f.strata, rep(names(f.survfit$strata)[f.i], f.survfit$strata[f.i]))
```

```
    }
```

```
    # create data.frame with data from survfit (create column for strata)
```

```
    f.frame <- data.frame(time=f.survfit$time, n.risk=f.survfit$n.risk, n.event=f.survfit$n.event, n.censor = f.survfit
      $n.censor, surv=f.survfit$surv, upper=f.survfit$upper, lower=f.survfit$lower, strata=factor(f.strata))
```

```
    # remove temporary data
```

```
    rm(f.strata)
```

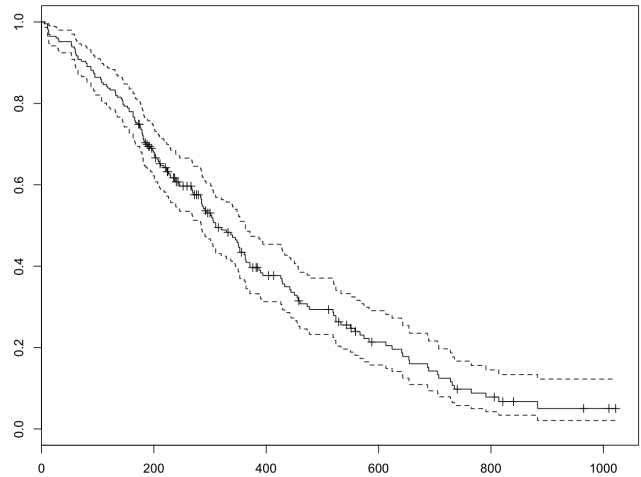
```
    # create first two rows (start at 1) for each strata
```

```
    for(f.i in 1:length(f.survfit$strata)){
```

```
      # take only subset for this strata from data
```

```
      f.subset <- subset(f.frame, strata==names(f.survfit$strata)[f.i])
```

```
      # create first two rows (time: 0, time of first event)
```



```

    f.start <- data.frame(time=c(0, f.subset$time[1]), n.risk=rep(f.survfit[f.i]$n, 2), n.event=c(0,0),
    n.censor=c(0,0), surv=c(1,1), upper=c(1,1), lower=c(1,1), strata=rep(names(f.survfit$strata)[f.i],
    2))

    # add first two rows to dataset
    f.frame <- rbind(f.start, f.frame)

    # remove temporary data
    rm(f.start, f.subset)

  }

  # reorder data
  f.frame <- f.frame[order(f.frame$strata, f.frame$time), ]

  # rename row.names
  rownames(f.frame) <- NULL
}

# return frame
return(f.frame)
}

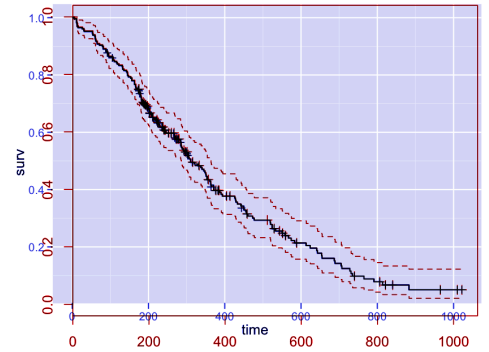
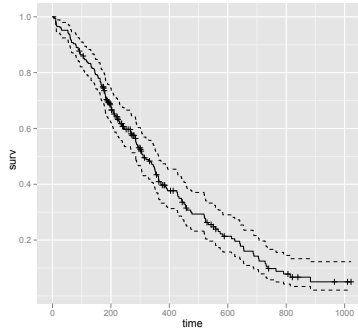
# define custom function to draw kaplan-meier curve with ggplot
qplot_survival <- function(f.frame, f.CI="default", f.shape=3){
  # use different plotting commands dependig whether or not strata's are given
  if("strata" %in% names(f.frame) == FALSE){
    # confidence intervals are drawn if not specified otherwise
    if(f.CI=="default" | f.CI==TRUE ){
      # create plot with 4 layers (first 3 layers only events, last layer only censored)
      # hint: censoring data for multiple censoring events at timepoint are overplotted
      # (unlike in plot.survfit in survival package)
      ggplot(data=f.frame) + geom_step(aes(x=time, y=surv), direction="hv") + geom_step(aes(x=time,
      y=upper), directions="hv", linetype=2) + geom_step(aes(x=time,y=lower), direction="hv", linetype=2) +
      geom_point(data=subset(f.frame, n.censor==1), aes(x=time, y=surv), shape=f.shape)
    }
    else {
      # create plot without confidence intervals
      ggplot(data=f.frame) + geom_step(aes(x=time, y=surv), direction="hv") +
      geom_point(data=subset(f.frame, n.censor==1), aes(x=time, y=surv), shape=f.shape)
    }
  }
  else {
    if(f.CI=="default" | f.CI==FALSE){
      # without CI
      ggplot(data=f.frame, aes(group=strata, colour=strata)) + geom_step(aes(x=time, y=surv),
      direction="hv") + geom_point(data=subset(f.frame, n.censor==1), aes(x=time, y=surv), shape=f.shape)
    }
    else {
      # with CI (hint: use alpha for CI)

```

```
ggplot(data=f.frame, aes(colour=strata, group=strata)) + geom_step(aes(x=time, y=surv),
direction="hv") + geom_step(aes(x=time, y=upper), directions="hv", linetype=2, alpha=0.5) +
geom_step(aes(x=time,y=lower), direction="hv", linetype=2, alpha=0.5) +
geom_point(data=subset(f.frame, n.censor==1), aes(x=time, y=surv), shape=f.shape)
```

```
}
}
}
```

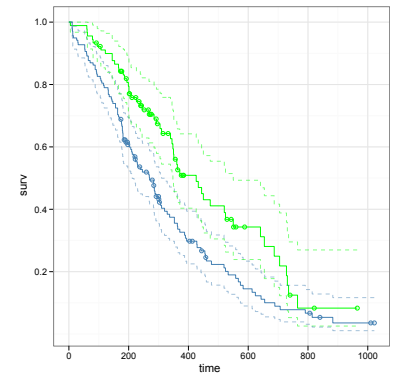
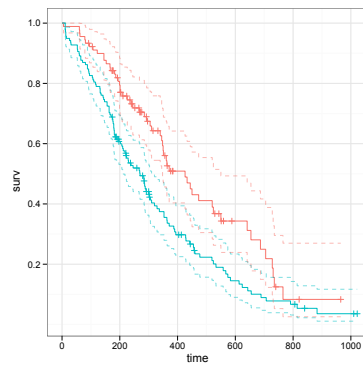
```
# create frame from survival class (survfit)
t.survfit <- survfit(t.Surv~1, data=lung)
t.survframe <- createSurvivalFrame(t.survfit)
```



overlay of `qplot_survival` and plot from survival package

```
# create kaplan-meier-plot with ggplot
qplot_survival(t.survframe)
```

```
# drawing survival curves with several strata
t.Surv <- Surv(lung$time, lung$status)
t.survfit <- survfit(t.Surv~sex, data=lung)
plot(t.survfit)
```



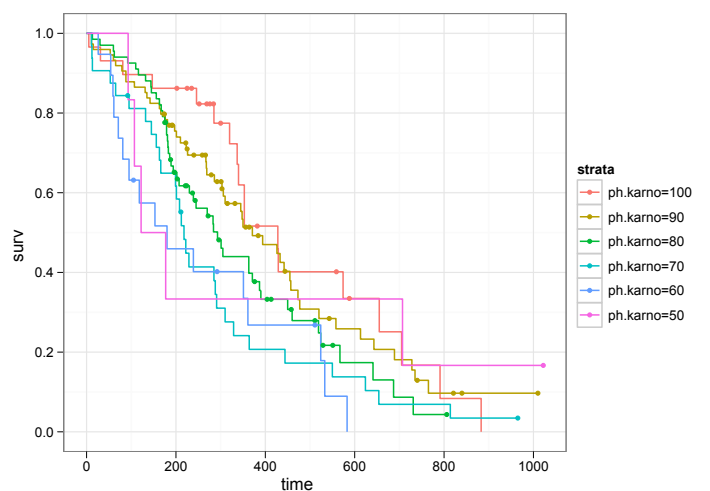
```
# two strata
t.survframe <- createSurvivalFrame(t.survfit)
qplot_survival(t.survframe)

# with CI
qplot_survival(t.survframe, TRUE)

# add ggplot options, use different shape
qplot_survival(t.survframe, TRUE, 1) + theme_bw() + scale_colour_manual(value=c("green", "steelblue")) +
opts(legend.position="none")
```

```
# multiple strata
t.survfit <- survfit(t.Surv~ph.karno, data=lung)
t.survframe <- createSurvivalFrame(t.survfit)
qplot_survival(t.survframe)

# plot without confidence intervals and with different shape
qplot_survival(t.survframe, FALSE, 20)
```



multiple plots in one graphic

define function to create multi-plot setup (nrow, ncol)

```
vp.setup <- function(x,y){
  # create a new layout with grid
  grid.newpage()
  # define viewports and assign it to grid layout
  pushViewport(viewport(layout = grid.layout(x,y)))
}
```

define function to easily access layout (row, col)

```
vp.layout <- function(x,y){
  viewport(layout.pos.row=x, layout.pos.col=y)
}
```

define graphics

```
p.a <- qplot(mpg, wt, data=mtcars, geom="point") +
  theme_bw()
```

```
p.b <- qplot(mpg, wt, data=mtcars, geom="bar",
  stat="identity")
```

```
p.c <- qplot(mpg, wt, data=mtcars, geom="step")
```

setup multi plot with grid

```
vp.setup(2,2)
```

plot graphics into layout

```
print(p.a, vp=vp.layout(1, 1:2))
```

```
print(p.b, vp=vp.layout(2,1))
```

```
print(p.c, vp=vp.layout(2,2))
```

