

25.04.23

Einführung in Data Science und maschinelles Lernen

GRAFISCHE DARSTELLUNG VON DATEN

- **Besprechung Aufgaben**
- **Nutzung von Sprachmodellen**
- **Selektion von Daten**
- **Einlesen von Daten aus externen Quellen**
- **Diagramm- und Skalentypen**
- **Struktur der Funktionen in ggplot**

BREAKOUT

- **Vergleicht Eure Lösungen oder Lösungsversuche zu den Übungsaufgaben**
- **Mit welchen Anweisungen oder ggf. Suchanfragen habt Ihr gearbeitet?**

TIPPS ZUR SUCHE MIT GOOGLE

- **Englisch**
- **Name der Programmiersprache oder des Packages, das man nutzt**
("R", "dplyr", "ggplot", ...)
- **Vollständige Fragen mit sinnvoller Reihenfolge der Wörter können besser sein**

+ New chat

- R-Library Datensatz aufbereit
- VW T3 Westfalia Liegefläche
- Docker: User Not Found.
- Docker Compose PostgreSQL
- External file for environment v
- Python Flask auto-reloading.
- Experten in Lehr-Lern-Forsch
- Pruning ML models.
- 4100K, 1900 lumen: Beratung
- HTML Button Desianina.

- Clear conversations
- Upgrade to Plus **NEW**
- Settings
- Get help
- Log out

ChatGPT



Examples

"Explain quantum computing in simple terms" →

"Got any creative ideas for a 10 year old's birthday?" →

"How do I make an HTTP request in Javascript?" →



Capabilities

Remembers what user said earlier in the conversation

Allows user to provide follow-up corrections

Trained to decline inappropriate requests



Limitations

May occasionally generate incorrect information

May occasionally produce harmful instructions or biased content

Limited knowledge of world and events after 2021

Send a message...

ChatGPT Mar 23 Version. Free Research Preview. ChatGPT may produce inaccurate information about people, places, or facts.

<https://chat.openai.com/>

TIPPS ZUR NUTZUNG VON CHATGPT

- **Deutsch oder Englisch scheint gleich gut zu funktionieren.**
- **Initialer Prompt der die generelle Ausrichtung des Chatbots bestimmt, z.B.:**
„Du bist ein hochentwickelter, präziser und moderner KI-Programmierassistent.“

TIPPS ZUR NUTZUNG VON CHATGPT

- **Beschreibung der Datenstruktur**
- **Beschreibung der Aufgabe – desto detaillierter, desto besser.**
- **Kopieren des Codes in RStudio.**
 - **Direkte Behebung von Fehlern**
 - **Rückmeldung der Fehlermeldung an ChatGPT**
- **Nutzung von ChatGPT, um Code zu erklären.**

Ask me anything...



0/1000

I need to throw a dinner party for 6 people who are vegetarian. Can you suggest a 3-course menu with a chocolate dessert?

Try it

Learn more

Ist das ein versteckter Wasserfall?

Silberrücken tritt an



Toter rettet Leben



'Wir sind zu kurz'



Villa in Flammen



Verrät Kriegsziele



Schlagzeilen

Vor Scholz-Besuch: Widerstand gegen geplantes LNG-Terminal...
Frankfurter Allgemeine Zeitung · 1 Stunde

Warburg-Bank: Bundestag berät die Einsetzung eines...
Berliner Zeitung · 3 Stunden

Hamburg

8 °C

Vereinzelt Regen



Welcome to the new Bing

Your AI-powered copilot for the web

Ask complex questions

Get better answers

Get creative inspiration

"What are some meals I can make for my picky toddler who only eats orange-coloured food?"

"What are the pros and cons of the top 3 selling pet vacuums?"

"Write a haiku about crocodiles in outer space in the voice of a pirate"

Let's learn together. Bing is powered by AI, so surprises and mistakes are possible. Make sure to check the facts, and [share feedback](#) so we can learn and improve!

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Choose a conversation style [Preview](#)

More Creative

More **Balanced**

More Precise

New topic

Ask me anything...

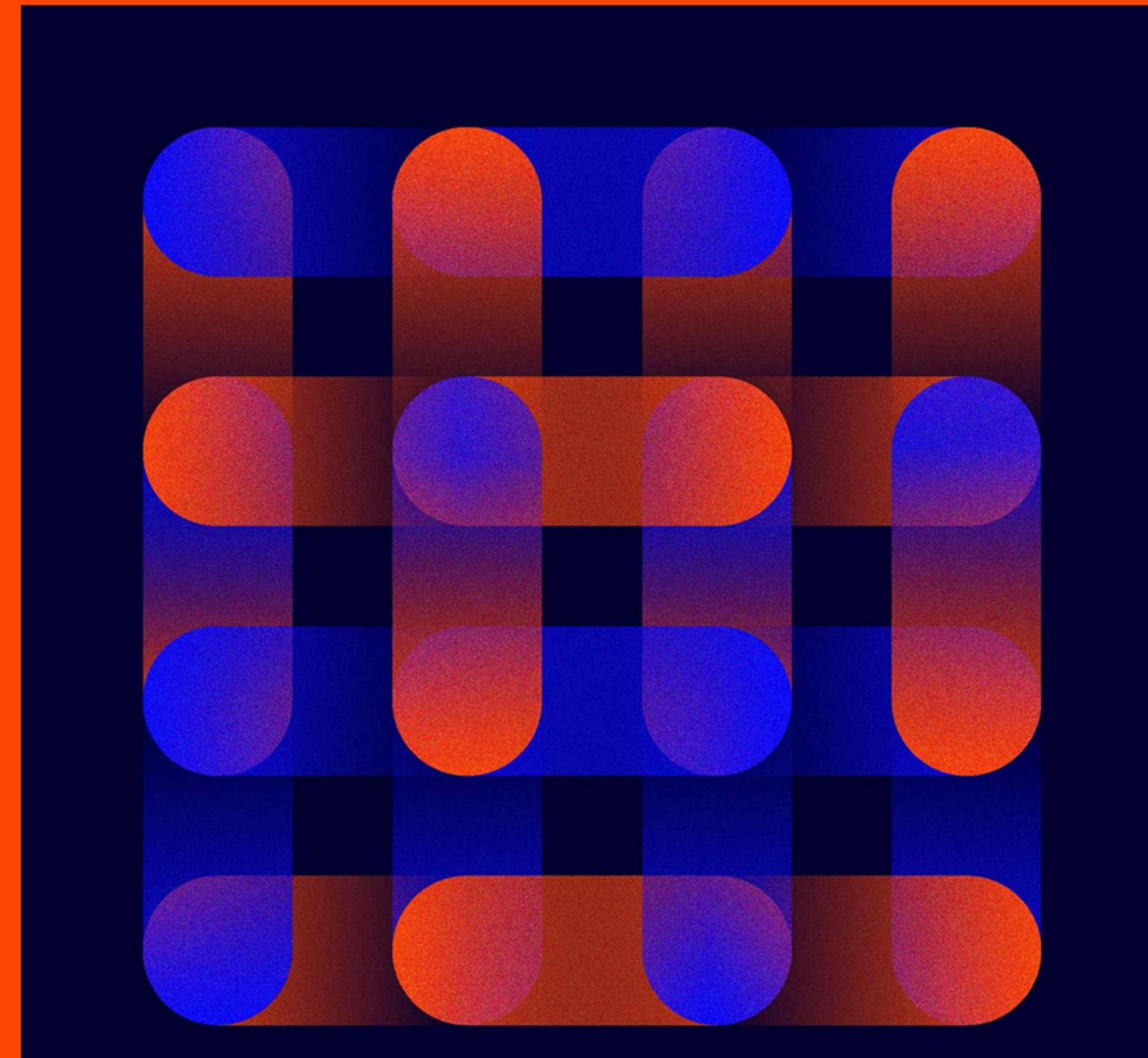
Feedback

OpenAI API

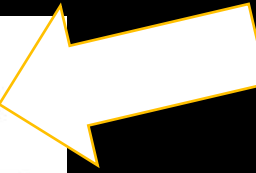
We're releasing an API for accessing new AI models developed by OpenAI.

[Sign up ↗](#)

[Explore the API](#)



<https://openai.com/blog/openai-api>



Welcome to OpenAI

Start with the basics

Quickstart tutorial
Learn by building a quick sample app

Examples
Explore some example tasks

Build an application

Chat Beta
Learn how to use chat-based language models

Text completion
Learn how to generate or edit text

Embeddings
Learn how to search, classify, and compare text

Speech to text Beta
Learn how to turn audio into text

Image generation Beta
Learn how to generate or edit images

Fine-tuning
Learn how to train a model for your use case

<https://platform.openai.com/overview>



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Learn how to train a model for your use case

- steffen@opencampus.sh
- opencampus.sh
- Manage account
- View API keys**
- Invite team
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- Help
- Pricing
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ORGANIZATION

opencampus.sh ⓘ

Settings

Usage

Members

Billing

USER

API keys

API keys

Your secret API keys are listed below. Please note that we do not display your secret API keys again after you generate them.

Do not share your API key with others, or expose it in the browser or other client-side code. In order to protect the security of your account, OpenAI may also automatically rotate any API key that we've found has leaked publicly.

NAME	KEY	CREATED	LAST USED ⓘ	
Secret key	sk- . . . Pvuc	18. März 2023	19. Apr. 2023	

+ Create new secret key

Default organization

If you belong to multiple organizations, this setting controls which organization is used by default when making requests with the API keys above.

opencampus.sh ▼

Note: You can also specify which organization to use for each API request. See [Authentication](#) to learn more.

Language models

Multiple models, each with different capabilities and price points. Prices are per 1,000 tokens. You can think of tokens as pieces of words, where 1,000 tokens is about 750 words. This paragraph is 35 tokens.

GPT-4

With broad general knowledge and domain expertise, GPT-4 can follow complex instructions in natural language and solve difficult problems with accuracy.

[Learn more](#)

Model	Prompt	Completion
8K context	\$0.03 / 1K tokens	\$0.06 / 1K tokens
32K context	\$0.06 / 1K tokens	\$0.12 / 1K tokens

Chat

ChatGPT models are optimized for dialogue. The performance of gpt-3.5-turbo is on par with Instruct Davinci.

[Learn more about ChatGPT](#)

Model	Usage
gpt-3.5-turbo	\$0.002 / 1K tokens



ENTER YOUR OPENAI API KEY

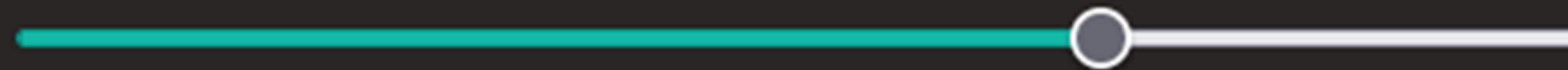
sk-...

SELECT MODEL

GPT4 8k - Most insightful, larger problems, slower



TEMPERATURE



Save

<https://shchat-gpt.vercel.app/>

ENTER YOUR OPENAI API KEY

sk-...

SELECT MODEL

GPT4 8k - Most insightful, larger problems, slower

GPT4 8k - Most insightful, larger problems, slower

GPT4 8k Snapshot - Most insightful, larger problems, slower.

GPT4 32k - Most insightful, larger problems, slower. Large Context-Window

GPT3.5 - A good balance between speed and insight

GPT3.5 Snapshot - A good balance between speed and insight

<https://shchat-gpt.vercel.app/>



Model: GPT4 8k



SYSTEM MESSAGE

You are a sophisticated, accurate, and modern AI programming assistant

OR

Pick a Template





Type a message ...










SYSTEM MESSAGE

You are a tutor that always responds in the Socratic style. You **never** give the student the answer, but always try to ask just the right question to help them learn to think for themselves. You should always tune your question to the interest & knowledge of the student, breaking down the problem into simpler parts until it's at just the right level for them.

OR

 Tutor - Never gives the answer but always helpful. 

Pick a Template

-  Generic - Helps you think
-  Tutor - Never gives the answer but always helpful.
-  Developer - Helps you code
-  Scientist - Helps you write scientific papers
-  Executive - Helps you write business emails
-  Catalyst - The growth hacker with marketing superpowers 

Type a message...

SELEKTION VON SPALTEN (VARIABLEN)

Am Beispiel des Data Frames zu `mtcars`

Selektion genau einer Spalte als *Vektor*

- `mtcars$mpg` **oder** `mtcars[["mpg"]]`
- `mtcars[[1]]`
- **besser nicht:** `mtcars[,c("mpg")]` **oder** `mtcars[,1]`

Selektion einer oder mehrerer Spalten als *Data Frame*

- `mtcars["mpg"]` **oder** `mtcars[c("mpg", "cyl")]`
- `mtcars[1]` **oder** `mtcars[c(1,2)]`
- **besser nicht:** `mtcars[,c("mpg", "cyl")]` **oder** `mtcars[,c(1,2)]`

SELEKTION VON ZEILEN (FÄLLEN)

Selektion einer oder mehrerer Zeilen als Data Frame

- `mtcars[1,]`
- `mtcars[c(1,2,3),]` **oder** `mtcars[c(1:3, 5:20),]`

Löschen einer oder mehrerer Zeilen

- `mtcars[-1,]`
- `mtcars[-c(1,3),]`

→ Selektion als Vektor nicht möglich / Keine Selektion über den Namen

SELEKTION MIT HILFE VON DPLYR

```
library (dplyr)
```

```
# Selektion von Spalten (Variablen) als Data Frame
```

```
select(mtcars, mpg, cyl)
```

```
select(mtcars, mpg)
```

```
# Selektion von Zeilen (Fällen)
```

```
slice(mtcars, 1:3, 5:20)
```

```
filter(mtcars, cyl==4)
```

WEITERER TIPP ZUR NUTZUNG VON GROßEN SPRACHMODELLEN (LLMS)

- **Gebt vor welche Library Ihr gerne benutzen möchtet**
- **Fragt explizit nach, welche Library für das gegebene Problem die beste ist bzw. schreibt explizit, dass die für das Problem optimale Library genutzt werden soll.**

SELEKTION MIT BOOLESCHEN VEKTOREN

- **Konstruktion des Vektors**

```
mtcars$hp < 100
```

```
mtcars$gear == 5
```

- **Selektion der Fälle (Zeilen) mit dem Wert TRUE**

```
mtcars[mtcars$hp<100, ] bzw. filter(mtcars, hp<100)
```

```
mtcars[mtcars$hp<100 & mtcars$gear==5, ] bzw.
```

```
filter(mtcars, hp<100 & gear==5)
```

BOOLESCHE OPERATOREN

- **UND:**
hp<100 & gear==5
- **ODER:**
hp<100 | gear==5
- **NICHT:**
!(hp<100 & gear==5)

ZUWEISUNG VS. VERGLEICH

- **Zuweisung von Objekten:**

`a <- x` (besser nicht: `a = x`)

- **Zuweisung von Funktionsargumenten:**

`mean(x, na.rm = TRUE)`

- **Vergleich von Objekten:**

`a == x`

SPEICHERN UND LADEN VON R- OBJEKTEN

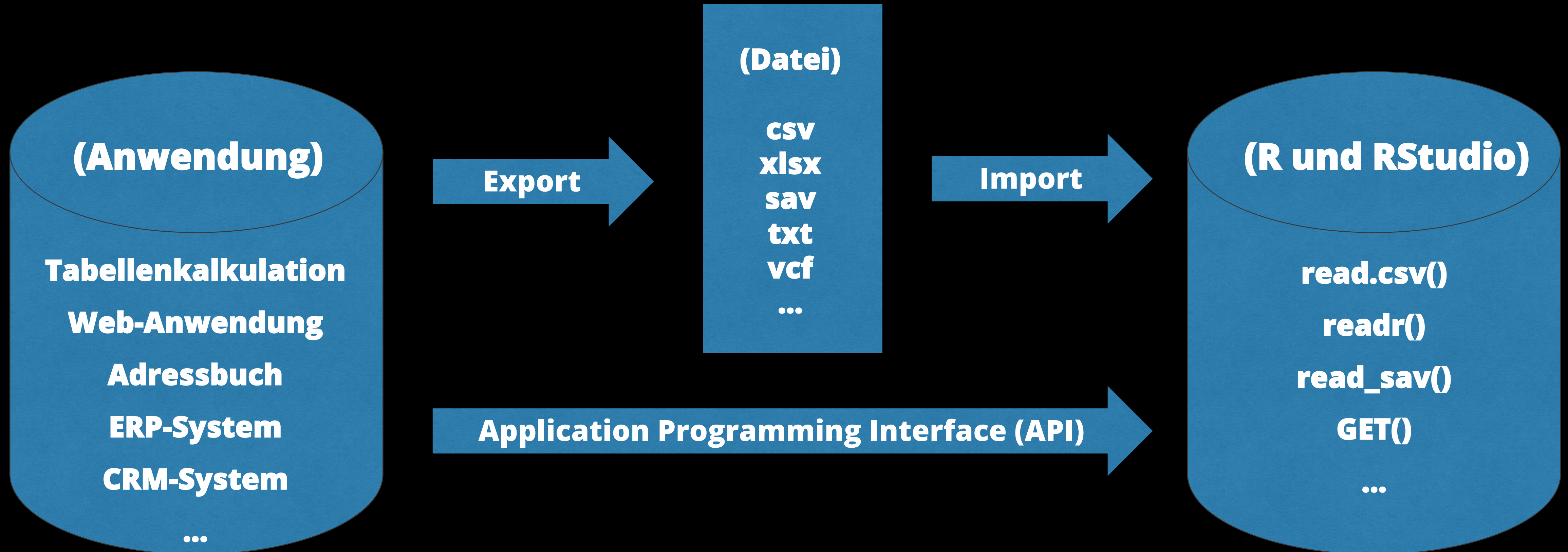
R-Objekte können sein:

- data table, variable, vector, function, list, graphical output, ...
- alles was auch in der Arbeitsumgebung von R enthalten sein kann

Alle R-Objekte können mit Hilfe der folgenden Funktionen gespeichert und geladen werden:

- `save(object_name, file="filename.Rda")`
- `load("filename.Rda")`

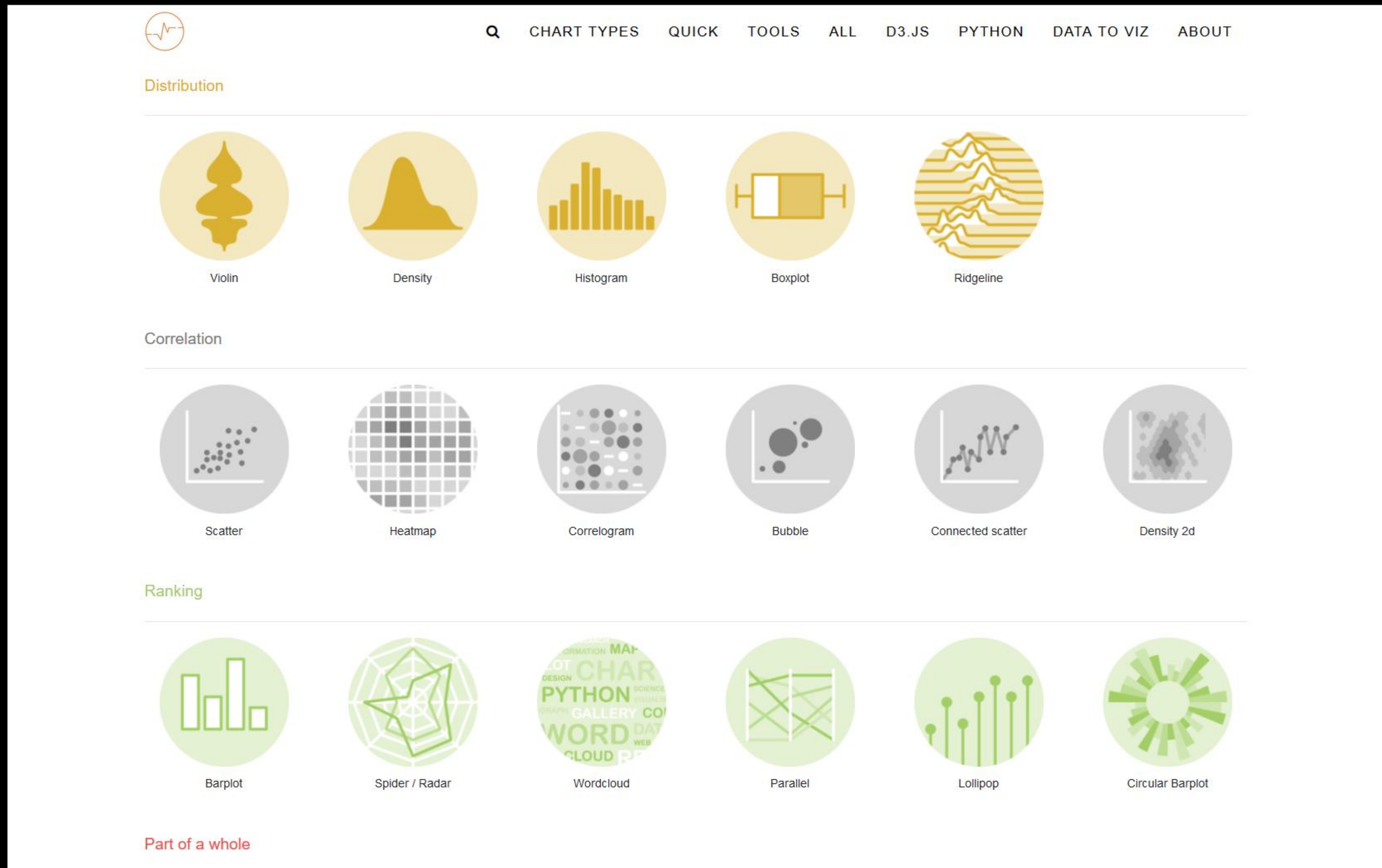
IMPORT VON DATEN



VORGEHEN ZUM IMPORT MIT HILFE VON LLMS

- **Anweisung die den Dateinamen, die Dateiendung und ggf. das Verzeichnis oder der Link unter dem die Datei zu finden ist.**
- **Insbesondere bei Textdateien ggf. ein Auszug vom Beginn der Datei in die Anweisung mit einfügen.**

DIAGRAMMTYPEN



<https://www.r-graph-gallery.com/>

SKALENTYPEN

- **Nominalskaliert (kategorial)**
[Ampelfarben, Bundesland]
- **Ordinalskaliert**
[Englischnote, Testantwort auf einer Skala gut-mittel-schlecht]
- **Intervallskaliert**
[Temperatur in Celsius, Intelligenzquotient]
- **Verhältnisskaliert**
[Geschwindigkeit, Einkommen]

GÄNGIGE DIAGRAMMTYPEN

- **Histogramm**
Darstellung der Verteilung einer numerischen (mind. ordinalen) Variable
- **Balkendiagramm (Barplot)**
Darstellung zwischen einer numerischen (mind. ordinalen Variable) und einer kategoriellen Variable
- **Scatterplot**
Darstellung der Beziehung von zwei numerischen (mind. ordinalen) Variablen

GGPLOT BASICS

- Eine ggplot Abbildung ist ein R-Objekt, das über eine beliebige Anzahl von „Layern“ definiert wird.
- Jedes Objekt wird mit `ggplot()` erzeugt.
- Die wichtigsten Layer sind:
 - Aesthetics* – `aes()`
Zurordnung von Daten zur Abbildung (x-Werte, y-Werte, Label, Farbwerte dargestellter Punkte, ...)
 - Geometries* – `geoms()`
Definition der Darstellungsform (Histogramm, Scatterplott, ...)
- Jeder Layer wird durch ein „+“ hinzugefügt.

WEITERE GGLOT LAYER

- ***Facets***
Layout von mehreren, nebeneinander dargestellten Abbildungen in einer Grafik
- ***Statistics***
Durchführung/Darstellung einfacher statistischer Funktionen
- ***Coordinates***
Definition/Layout des Raums, in dem die Daten dargestellt werden.
- ***Themes***
Selektion von Templates mit unterschiedlichen (datenunabhängigen) Voreinstellungen

BEISPIEL SCATTERPLOT

```
ggplot() +  
  aes(x = mpg$hwy, y = mpg$cty) +  
  geom_point()
```

Grundlegende Datentabelle ist nicht definiert,
Datentabelle muss also immer angegeben werden.

```
ggplot(mpg) +  
  aes(x = hwy, y = cty) +  
  geom_point()
```

Grundlegende Datentabelle wird für alle
nachfolgenden Layer definiert.

```
ggplot(mpg) +  
  geom_point(aes(x = hwy, y = cty))
```

Aesthetics werden nur speziell für diesen
Layer definiert.

WEITERE BEISPIELE

(siehe Beispielcode zu dieser Woche)

Scatterplot

```
ggplot(mpg)+  
  geom_point(aes(x = hwy, y = cty, color = displ))
```

Histogramm

```
ggplot(mpg)+  
  geom_histogram(aes(x = cty))
```

Balkendiagramm

```
ggplot(mtcars)+  
  geom_bar(aes(x = as.factor(cyl), y = mpg), stat = "identity")
```

ERSTELLUNG VON GGPLOTS

- 1) Auswahl eines Diagramms aus R Graph Gallery**
- 2) Ausführen des in der Graph Gallery gegebenen Beispielcodes**
- 3) Ersetzen der gegebenen Beispieldaten durch eigene (nutze ein LLM)**
- 4) Anpassen des Diagramms durch Anweisung an das LLM oder über Hilfe-Seiten**

PROJEKTDATENSATZ

- **Zur Verfügung gestellt von Meteolytix**
- **Umsatzdaten von verschiedenen Warengruppen einer Bäckereifiliale für den Zeitraum vom 01.07.2013 bis zum 08.06.2019**
- **Wetterdaten für den Zeitraum vom 01.07.2013 bis zum 30.07.2019**

- **Abrufbar unter:**

https://raw.githubusercontent.com/opencampus-sh/einfuehrung-in-data-science-und-ml/main/umsatzdaten_gekuerzt.csv



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opencampus-sh / einfuehrung-in-data-science-und-ml

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main

einfuehrung-in-data-science-und-ml / umsatzdaten_gekuerzt.csv

Go to file



steffen74 Datensatz Sommersemester 2022

Latest commit fd081db 9 minutes ago

History

1 contributor

10910 lines (10910 sloc)

319 KB

Raw

Blame



Search this file...

1	Datum	Warengruppe	Umsatz
2	2013-07-01	1	148.828353112183
3	2013-07-02	1	159.79375714468
4	2013-07-03	1	111.885593514353
5	2013-07-04	1	168.864940979931
6	2013-07-05	1	171.280754117955
7	2013-07-06	1	174.552359998476
8	2013-07-07	1	92.6377553788373

WARENGRUPPEN

- 1 Brot**
- 2 Brötchen**
- 3 Croissant**
- 4 Konditorei**
- 5 Kuchen**
- 6 Saisonbrot**

WETTERDATEN

- **für den Zeitraum vom 01.07.2013 bis zum 30.07.2019**
- **Abrufbar unter:**
<https://raw.githubusercontent.com/opencampus-sh/einfuehrung-in-data-science-und-ml/main/wetter.csv>
- **Variablen:**
 - **mittlerer Bewölkungsgrad am Tag (0: min bis 8: max)**
 - **mittlere Temperatur in Celsius**
 - **mittlere Windgeschwindigkeit in m/s**
 - **Wettercode (eine Liste mit Beschreibungen gibt es z.B. hier: http://www.seewetter-kiel.de/seewetter/daten_symbole.htm)**



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[einfuehrung-in-data-science-und-ml](#) / [wetter.csv](#)

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[steffen74](#) Project Data

Latest commit [c61a127](#) on 20 Apr 2021

[History](#)

[1 contributor](#)

2602 lines (2602 sloc) | 64.2 KB

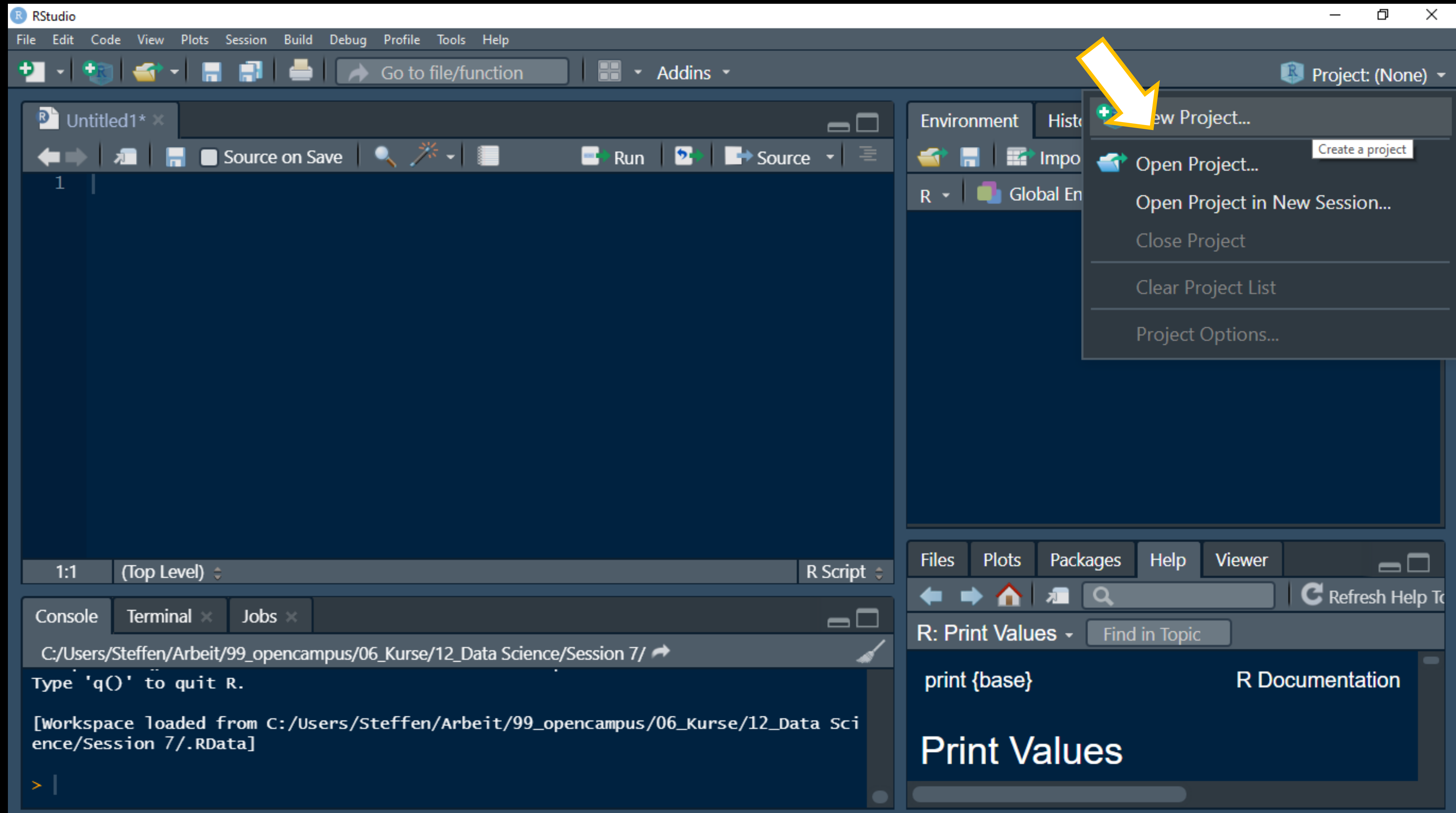
[Raw](#)

[Blame](#)



1	Datum	Bewoelkung	Temperatur	Windgeschwindigkeit	Wettercode
2	2012-01-01	8	9.825	14	58
3	2012-01-02	7	7.4375	12	
4	2012-01-03	8	5.5375	18	63
5	2012-01-04	4	5.6875	19	80
6	2012-01-05	6	5.3	23	80
7	2012-01-06	3	2.625	10	
8	2012-01-07	7	6.528571	14	61

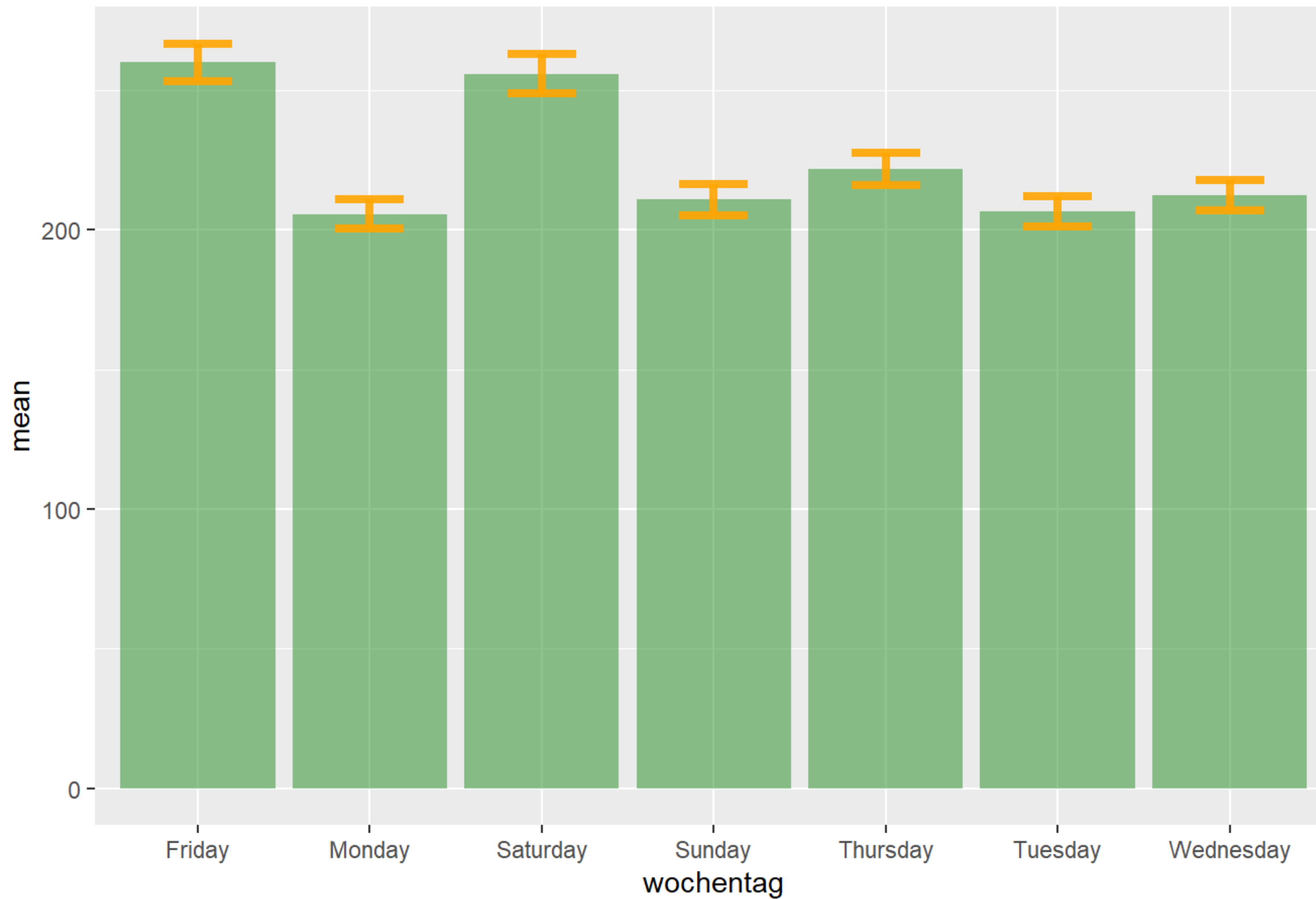
RSTUDIO-PROJEKT



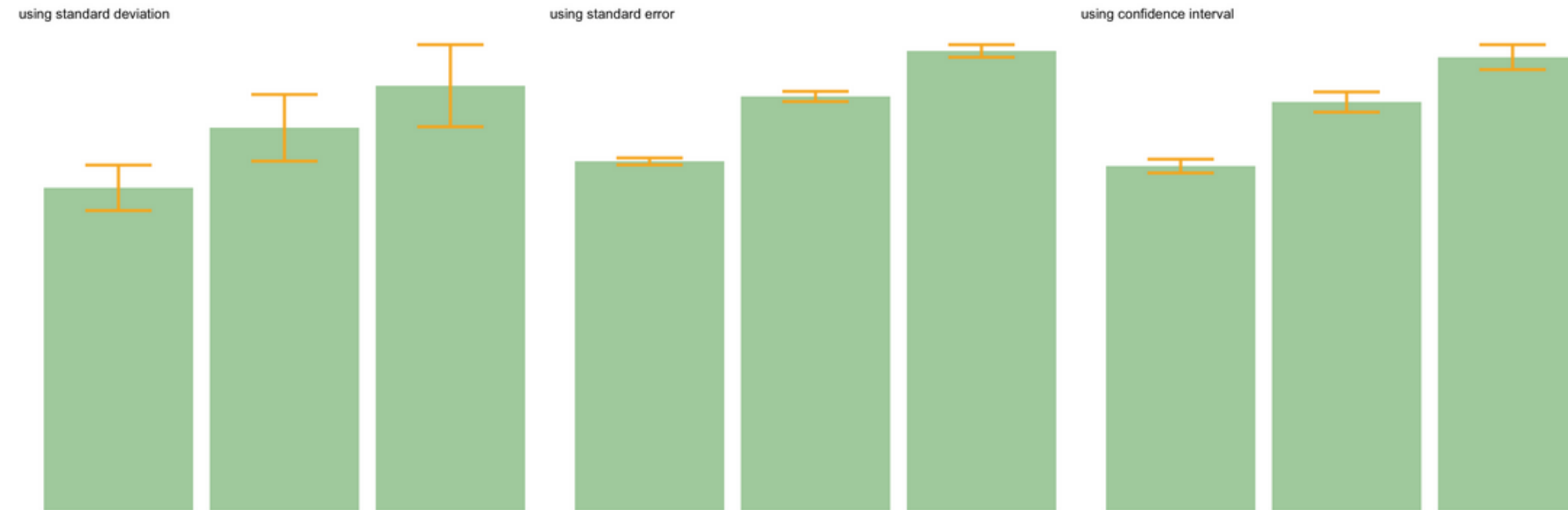
AUFGABEN

- **Lege ein R-Studio-Projekt-Verzeichnis an und speichere dort die Dateien „kiwo.csv“, „umsatzdaten_gekuerzt.csv“ und „wetter.csv“ aus diesem GitHub-Repository:**
<https://github.com/opencampus-sh/einfuehrung-in-data-science-und-ml>
- **Erstelle ein Balkendiagramm, das über alle Warengruppen hinweg die durchschnittlichen Umsätze je Wochentag zeigt.**
- **Füge in einem zweiten Schritt zusätzlich Konfidenzintervalle der Umsätze je Wochentag hinzu („barplot with error bars“).**
- **Stelle die Umsätze je Wochentag getrennt nach Warengruppe dar (ein eigenes Balkendiagramm je Warengruppe)**

using confidence interval



Standard deviation, Standard error or Confidence Interval?



Three different types of values are commonly used for error bars, sometimes without even specifying which one is used. It is important to understand how they are calculated, since they give very different results (see above). Let's compute them on a simple vector:

```
vec=c(1,3,5,9,38,7,2,4,9,19,19)
```

→ Standard Deviation (SD). [wiki](#)

It represents the amount of dispersion of the variable. Calculated as the root square of the variance:

```
sd <- sd(vec)  
sd <- sqrt(var(vec))
```

→ Standard Error (SE). [wiki](#)

It is the standard deviation of the vector sampling distribution. Calculated as the SD divided by the square root of the sample size. By construction, SE is

STARTHILFE

```
# Import needed libraries
```

```
library(readr)
```

```
library(lubridate)
```

```
library(ggplot2)
```

```
library(dplyr)
```

```
# Import turnover data
```

```
umsatzdaten <- read_csv("https://raw.githubusercontent.com/opencampus-sh/einfuehrung-in-data-science-und-ml/main/umsatzdaten_gekuerzt.csv")
```

```
# Create variable weekday
```

```
umsatzdaten$wochentag <- weekdays(umsatzdaten$Datum)
```

Reference

Plot basics


All ggplot2 plots begin with a call to `ggplot()`, supplying default data and aesthetic mappings, specified by `aes()`. You then add layers, scales, coords and facets with `+`. To save a plot to disk, use `ggsave()`.

<code>ggplot()</code>	Create a new ggplot
<code>aes()</code>	Construct aesthetic mappings
<code>`+` (<gg>)`</code> <code>`%+%`</code>	Add components to a plot
<code>ggsave()</code>	Save a ggplot (or other grid object) with sensible defaults
<code>qplot()</code> <code>quickplot()</code>	Quick plot

Layers

Geoms

A layer combines data, aesthetic mapping, a geom (geometric object), a stat (statistical transformation), and a position adjustment. Typically, you will create layers using a `geom_` function, overriding the default position and stat if needed.

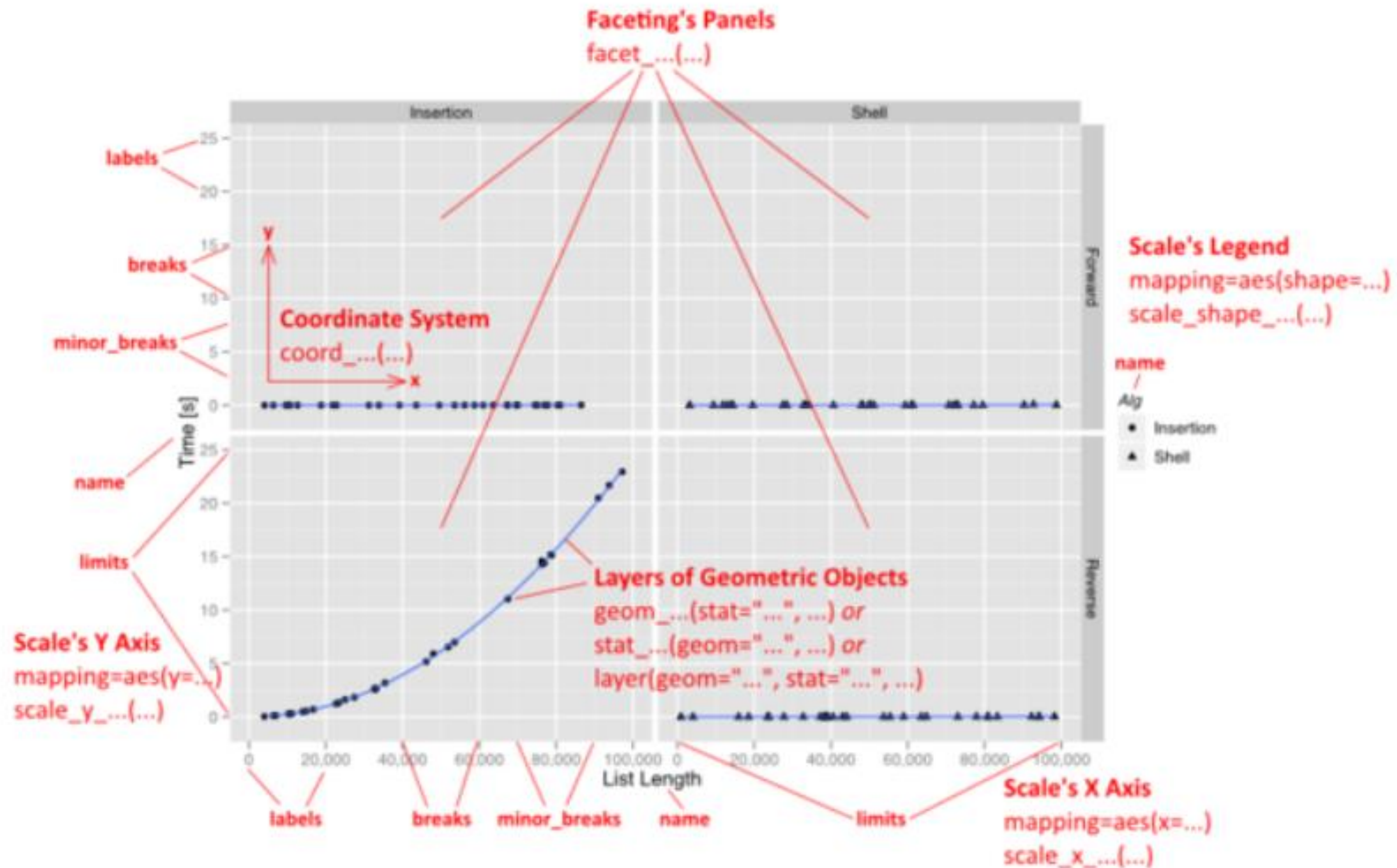
 `geom_abline()` `geom_hline()` Reference lines: horizontal, vertical, and diagonal
`geom_vline()`

Contents

- Plot basics
- Layers
- Aesthetics
- Scales
- Guides: axes and legends
- Facetting
- Coordinate systems
- Themes
- Programming with ggplot2
- Extending ggplot2
- Vector helpers
- Data
- Autoplot and fortify

Übersicht über existierende Layer und den Funktionen, die existieren.

<https://ggplot2.tidyverse.org/reference/>



Gute bildliche Darstellung der Elemente einer Abbildung:

<http://sape.inf.usi.ch/quick-reference/ggplot2>

GGPlot Cheat Sheet for Great Customization

 [kassambara](#) |  17/11/2017 |  36049 |  Comments (2) |  R Graphics Essentials

This chapter provides a cheat sheet to change the global appearance of a ggplot.

You will learn how to:

- Add title, subtitle, caption and change axis labels
- Change the appearance - color, size and face - of titles
- Set the axis limits
- Set a logarithmic axis scale
- Rotate axis text labels
- Change the legend title and position, as well, as the color and the size
- Change a ggplot theme and modify the background color
- Add a background image to a ggplot
- Use different color palettes: custom color palettes, color-blind friendly palettes, RColorBrewer palettes, viridis color palettes and scientific journal color palettes.
- Change point shapes (plotting symbols) and line types
- Rotate a ggplot
- Annotate a ggplot by adding straight lines, arrows, rectangles and text.

Contents:

- [Prerequisites](#)
- [Titles and axis labels](#)

How-To's mit verschiedenen Beispielen

www.sthda.com/english/articles/32-r-graphics-essentials/125-ggplot-cheat-sheet-for-great-customization/

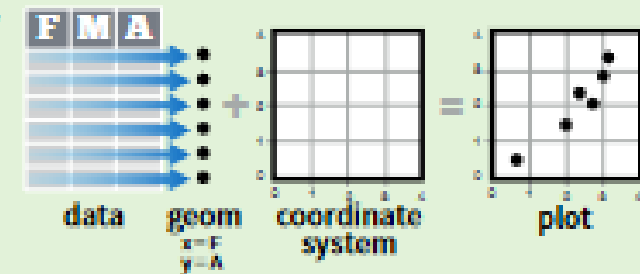
Data Visualization with ggplot2

Cheat Sheet

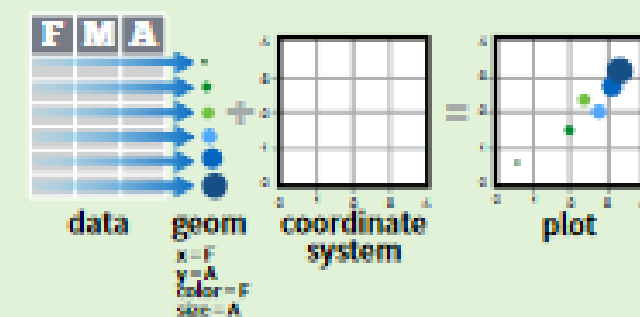


Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same few components: a **data** set, a set of **geoms**—visual marks that represent data points, and a **coordinate system**.



To display data values, map variables in the data set to aesthetic properties of the geom like **size**, **color**, and **x** and **y** locations.



Build a graph with `qplot()` or `ggplot()`

aesthetic mappings **data** **geom**

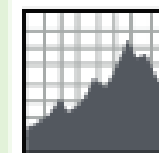
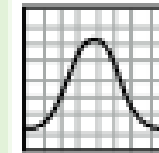
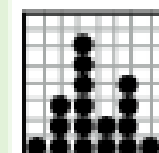
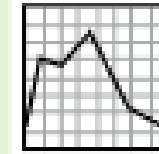
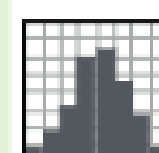
`qplot(x = cty, y = hwy, color = cyl, data = mpg, geom = "point")`
Creates a complete plot with given data, geom, and mappings. Supplies many useful defaults.

Geoms - Use a geom to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

One Variable

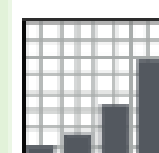
Continuous

`a <- ggplot(mpg, aes(hwy))`

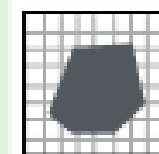
-  **a + geom_area(stat = "bin")**
x, y, alpha, color, fill, linetype, size
b + geom_area(aes(y = ..density..), stat = "bin")
-  **a + geom_density(kernel = "gaussian")**
x, y, alpha, color, fill, linetype, size, weight
b + geom_density(aes(y = ..county..))
-  **a + geom_dotplot()**
x, y, alpha, color, fill
-  **a + geom_freqpoly()**
x, y, alpha, color, linetype, size
b + geom_freqpoly(aes(y = ..density..))
-  **a + geom_histogram(binwidth = 5)**
x, y, alpha, color, fill, linetype, size, weight
b + geom_histogram(aes(y = ..density..))

Discrete

`b <- ggplot(mpg, aes(fl))`

-  **b + geom_bar()**
x, alpha, color, fill, linetype, size, weight

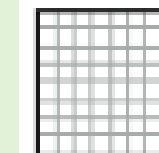
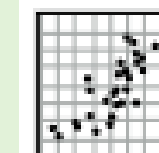
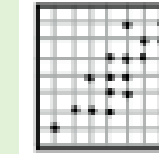
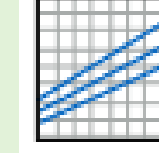
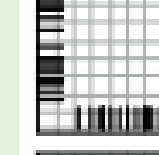
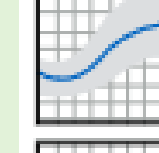
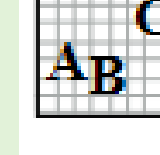
Graphical Primitives

- `c <- ggplot(map, aes(long, lat))`
-  **c + geom_polygon(aes(group = group))**
x, y, alpha, color, fill, linetype, size

Two Variables

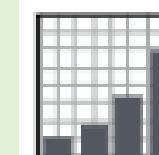
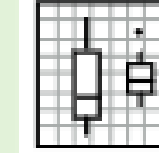
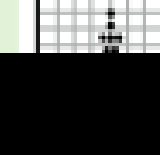
Continuous X, Continuous Y

`f <- ggplot(mpg, aes(cty, hwy))`

-  **f + geom_blank()**
-  **f + geom_jitter()**
x, y, alpha, color, fill, shape, size
-  **f + geom_point()**
x, y, alpha, color, fill, shape, size
-  **f + geom_quantile()**
x, y, alpha, color, linetype, size, weight
-  **f + geom_rug(sides = "bl")**
alpha, color, linetype, size
-  **f + geom_smooth(model = lm)**
x, y, alpha, color, fill, linetype, size, weight
-  **f + geom_text(aes(label = cty))**
x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

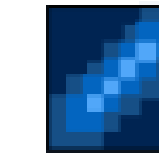
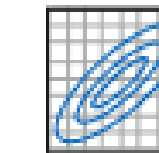
Discrete X, Continuous Y

`g <- ggplot(mpg, aes(class, hwy))`

-  **g + geom_bar(stat = "identity")**
x, y, alpha, color, fill, linetype, size, weight
-  **g + geom_boxplot()**
lower, middle, upper, x, ymax, ymin, alpha, color, fill, linetype, shape, size, weight
-  **g + geom_dotplot(binaxis = "y",**

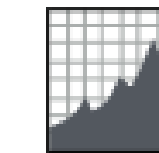
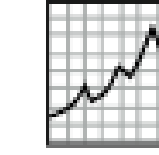
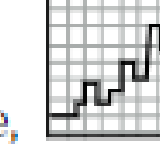
Continuous Bivariate Distribution

`i <- ggplot(movies, aes(year, rating))`

-  **i + geom_bin2d(binwidth = c(5, 0.5))**
xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size, weight
-  **i + geom_density2d()**
x, y, alpha, colour, linetype, size
-  **i + geom_hex()**
x, y, alpha, colour, fill size

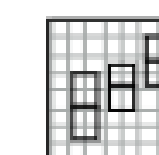
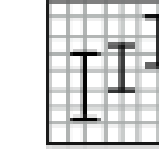
Continuous Function

`j <- ggplot(economics, aes(date, unemploy))`

-  **j + geom_area()**
x, y, alpha, color, fill, linetype, size
-  **j + geom_line()**
x, y, alpha, color, linetype, size
-  **j + geom_step(direction = "hv")**
x, y, alpha, color, linetype, size

Visualizing error

`df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)`
`k <- ggplot(df, aes(grp, fit, ymin = fit-se, ymax = fit+se))`

-  **k + geom_crossbar(fatten = 2)**
x, y, ymax, ymin, alpha, color, fill, linetype, size
-  **k + geom_errorbar()**
x, ymax, ymin, alpha, color, linetype, size, width (also `geom_errorbarh()`)
-  **k + geom_linerange()**
x, ymin, ymax, alpha, color, linetype, size

Cheat-Sheet von RStudio

<https://www.rstudio.com/wp-content/uploads/2015/03/ggplot2-cheatsheet.pdf>