Universität Hamburg
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FAKULTÄT
FÜR MATHEMATIK, INFORMATIK
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Thesis title

submitted by

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Abstract

The abstract comes always first and should raise the readers interest in reading further.

The abstract summarizes, usually in one or two paragraph (here max. 1 page), the major aspects of the entire thesis in a prescribed sequence. This should include:

- the overall purpose of the study and the research problem(s) you investigated
- the basic design of the study
- the major findings or trends found as a result of your analysis
- a brief summary of your interpretations and conclusions.

Zusammenfassung

The thesis should always provide a German summary after the abstract, independent of the language of the main sections. Its content should not deviate from the abstract.

List of Abbreviations

You can provide a table of abbreviations in R Markdown syntax or LaTeXsyntax. But if you do the former, R will count this table and, consequently, the next actual table will start with the counter 2:

ATP	Adenosine Triphosphate
CoA	Coenzyme A
DNA	Deoxyribonucleic Acid
mtDNA	Mitochondrial DNA

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1 Introduction

The introduction should move from the general to the specific. Address the following points:

- What is the general topic and why is it relevant?
- What is the current state of research? Which gaps or contradictions exist?
- What is the specific research question of this thesis?
- Which hypotheses are tested?
- How is the thesis structured? (chain of argumentation, subproblems)

1.1 Literature tips

Use Google Scholar or Web of Science (accessible via UHH VPN) to find relevant publications. Further useful databases in biology include the Electronic Journals Library of the UHH and ScienceDirect.

A reference manager such as Zotero (with the Better BibTeX plugin) helps organise your sources and export `.bib` files automatically. For citation syntax and bibliography setup, see the tutorial.

2 Material and Methods

The structure of this chapter depends very much on the type of research study, whether it is a field, laboratory or modelling study or a literature review. For field studies, the typical subsections are the

- study site
- experimental set-up
- sampling design
- statistical analysis with information on the used computer program [1]

2.1 Study site

External images (e.g. maps) are embedded with `knitr::include_graphics()`. The caption is set via `fig.cap` and the display width via `out.width`:

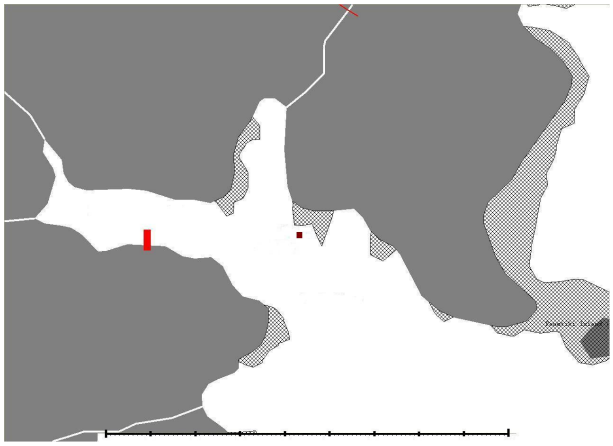

Figure 1: Location of sampling site....

2.2 Cross-references

Figures are referenced with `\@ref(fig:<chunk-label>)`, tables with `\@ref(tab:<chunk-label>`
Chunk labels must **not** contain underscores — use hyphens instead. Sections can be linked via `[Section name]`, e.g. Discussion. For a full overview, see the tutorial.

2.3 Mathematical equations

Inline equations use single dollar signs: $E = mc^2$. Display equations use double dollar signs:

$$E = mc^2$$

[1] such as R - this is an example of a footnote

For numbered equations with cross-references, use the LaTeXequation environment (see eq. (1)):

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n} \tag{1}$$

Formulas should be integrated into sentences and end with a comma or period.

2.4 Chemical formulas

Use `$\mathrm{...}$` to avoid automatic italicisation in math mode:

- Subscript: CH_4
- Superscript: O^-
- Combined: $Fe_2^{2+}Cr_2O_4$ via `$\mathrm{Fe_2^{2+}Cr_2O_4}$`
- Hydrate bullet: $CuCl \bullet 7H_2O$
- Arrows: $\longrightarrow$ (reaction), $\rightleftharpoons$ (reversible), $\leftrightarrow$ (resonance)
- Delta: Δ

Numbered reaction equations use the equation environment:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O \tag{2}$$

Reference via (2). Unnumbered inline reactions use dollar signs: $NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$

2.5 Software

This section should always come at the end of the method chapter. You should list here the R version you used and each package with its version number, including the reference. The following text creates everything necessary automatically. You only need to update the packages used:

All analyses were performed using the statistical software R (version 4.5.2) (R Core Team, 2025). This thesis, including tables, was generated using the packages 'bookdown' (version 0.46) (Xie, 2025a), 'rmarkdown' (version 2.30) (Allaire et al., 2025), 'knitr' (version 1.51) (Xie, 2025b), 'kableExtra' (version 1.4.0) (Zhu, 2024), and 'flextable' (version 0.9.10) (Gohel and Skintzos, 2025).

3 Results

The result chapter is of great importance in an empirical study and should comprise a good mix of text, tables and figures. Use your research questions and hypothesis for structuring this chapter to provide the reader some structure and to not lose the thread.

Figures and tables should be continuously numbered and referred to in the main text. LaTeXplaces figures and tables automatically were they fit best, which is sometimes on the next page. This is fine since they are cross-referenced anyway.

Tables have generally a caption at the top, while figures have a caption at the bottom. This has to be considered in some of the R functions (see below).

3.1 Tables

3.1.1 R Markdown table

Table 1 is a R Markdown table including a caption and label for cross-referencing. The caption is set with **Table: ...** and can come before or after the table. You do not need so set a number as LaTeXwill take care of the numbering as well as the placing. Also note that the caption requires no quotation marks.

The label is set **right after** the table caption with `\label{tab:name}`. **Note here** that this is LaTeXnotation, where brackets are **curly**, not round! Also when cross-referencing R Markdown tables use the LaTeXnotation `\ref{tab:name}` (i.e., no `@` and curly brackets).

Table 1: This is a table written in R Markdown.

A	New	Table
left-aligned	center-aligned	right-aligned
$123	$456	$789
italics	normal	**boldface**

3.1.2 Tables generated with R

Creating tables with R and packages like *knitr* and *kableExtra* is much easier (and protects against typing errors!) than manually entering values into a table by copying and pasting them into Excel or LaTeX. This shows once again how beautiful reproducible documents can be!

3.1.2.1 Using the *knitr* and *kableExtra* packages

Table 2 is an example of using `knitr::kable` to generate the table and *kableExtra* functions to modify it. `knitr::kable()` has an explicit argument named `caption` where you can place your caption text.

Table 2: This is a table produced with knitr and modified with kableextra.

	Group 5				Group 6	
	Group 1		Group 2		Group 3	Group 4
	mpg	cyl	disp	hp	drat	wt
Mazda RX4	21.0	6	160	110	3.90	2.620
Mazda RX4 Wag	21.0	6	160	110	3.90	2.875
Datsun 710	22.8	4	108	93	3.85	2.320
Hornet 4 Drive	21.4	6	258	110	3.08	3.215
Hornet Sportabout	18.7	8	360	175	3.15	3.440

Note:
Your comments go here.

3.1.2.2 The *flextable* package

flextable creates tables that work across PDF and Word output, making it a versatile choice. Table 3 shows an example. Note that `flextable` uses the `set_caption()` function for cross-referenceable captions:

Table 3: This is a table produced with flextable.

mpg	cyl	disp	hp	drat	wt
21.0	6	160	110	3.90	2.620
21.0	6	160	110	3.90	2.875
22.8	4	108	93	3.85	2.320
21.4	6	258	110	3.08	3.215
18.7	8	360	175	3.15	3.440

> **Tip:** Another excellent table package is gt, which provides a tidyverse-friendly grammar of tables. However, its PDF support is still maturing, so `kableExtra` (PDF) and `flextable` (PDF + Word) remain the most reliable choices for theses.

3.2 Figures

Figures can directly be produced with R and displayed here. Since most students use *ggplot2*, the examples below use it. Similar to external images, figure captions and labels are placed inside the chunk options for cross-referencing (see Figure 2).

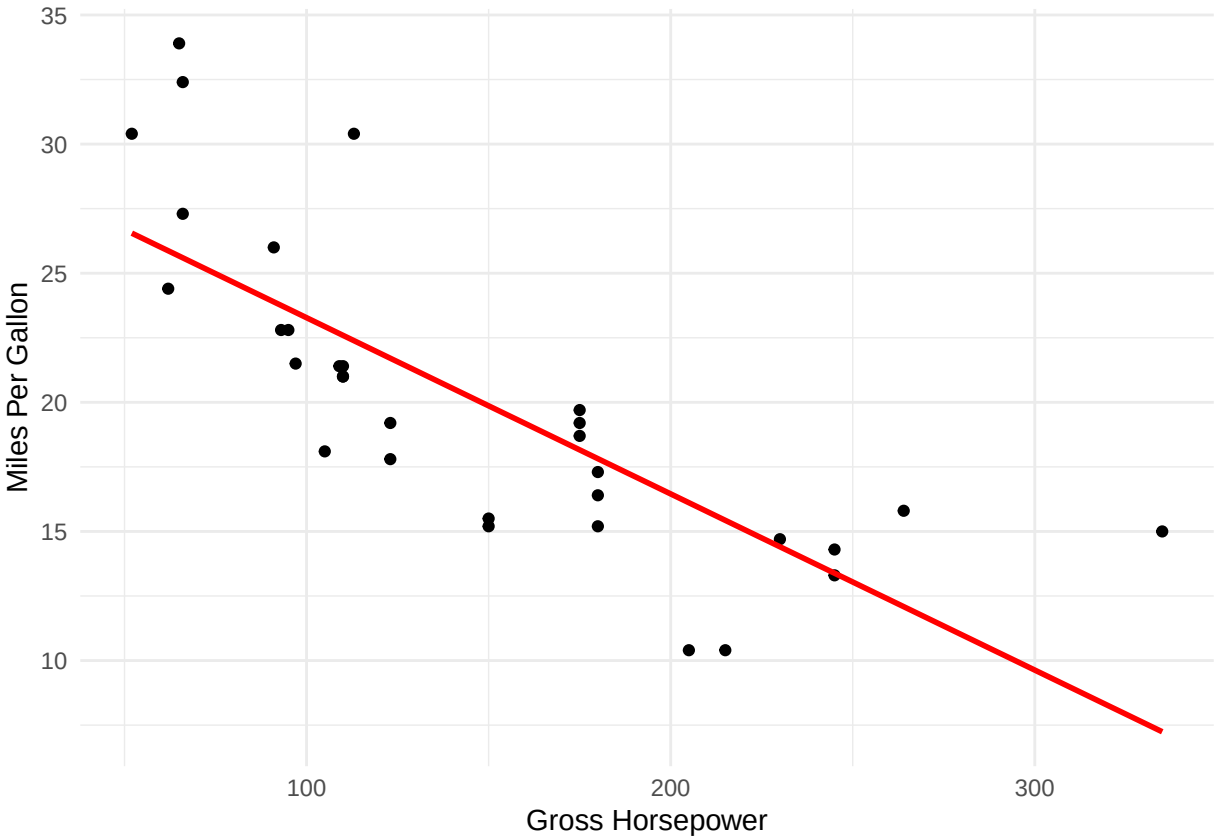

Figure 2: Relationship between horsepower and fuel economy.

Purely for demonstration purposes, Figure 3 shows a boxplot with just half the width and centered:

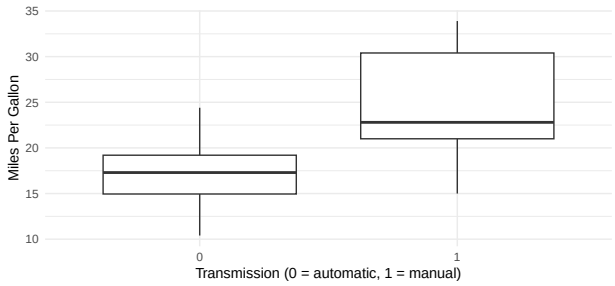

Figure 3: Fuel differences between transmission types (0 = automatic, 1 = manual).

4 Discussion

Providing strict guidelines and rules for a good discussion is difficult. But the following recommendations might be helpful:

- The discussion follows the opposite structure than the introduction and should move from the specific to the more general topics.
- Summary/recapitulation: You should start the discussion with a short summary of your main results and whether they support your hypothesis/hypotheses or not. Avoid here any statistical language as in the result section. You should again sketch out your line of argumentation in this section.
- Continue with the main messages of your empirical or theoretical study or your literature review: What are new insights from your results?
- Discussion of individual findings: expose results concisely and evaluate them critically. Potential questions that could be addressed here:
  - Are the findings convincing?
  - In empirical studies: which conclusions about the problem studied can be drawn? What are the implications of your findings? Which theories and previous studies support your results, which are contradicting?
  - In literature reviews: how many of the publications included in your analyses were high-quality and most recent? How many were outdated or had methodological flaws? Is there consensus across studies? Or are there group of studies that found different results?
  - Which questions remain still unanswered? Which come out as important due to your findings?
- Point out the limitations of your study (assist reader in judging validity of findings). Are there any results that contradict your hypothesis and how can they be explained? Discuss to which extent your results can be generalized.

4.1 Conclusion

- Which *take home messages* do you like to give the reader? What is the relevance of your study for future research and potential applications? Suggest issues for future research.
- One *final sentence* the complete the thesis.

5 References

Allaire J, Xie Y, Dervieux C, et al. (2025) *Rmarkdown: Dynamic Documents for r*. Available at: https://github.com/rstudio/rmarkdown.

Gohel D and Skintzos P (2025) *Flextable: Functions for Tabular Reporting*. Available at: https://ardata-fr.github.io/flextable-book/.

R Core Team (2025) *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. Available at: https://www.R-project.org/.

Xie Y (2025a) *Bookdown: Authoring Books and Technical Documents with r Markdown*. Available at: https://github.com/rstudio/bookdown.

Xie Y (2025b) *Knitr: A General-Purpose Package for Dynamic Report Generation in r*. Available at: https://yihui.org/knitr/.

Zhu H (2024) *kableExtra: Construct Complex Table with Kable and Pipe Syntax*. Available at: http://haozhu233.github.io/kableExtra/.

A Acknowledgements

I want to thank the following people ...

B Appendix

All relevant information has to be included in the main text. Irrelevant information as to be completely left out. Content that is related to the topic but not essential can be included in the appendix. Such could be the derivation of equations, additional information on statistical or laboratory analyses, source code of computer programs or any other comprehensive (data) material.

The appendix has to be similar to figures and tables cross-referenced and should **not** stand by itself. All figures and tables in the appendix should also have captions.

B.1 Figures

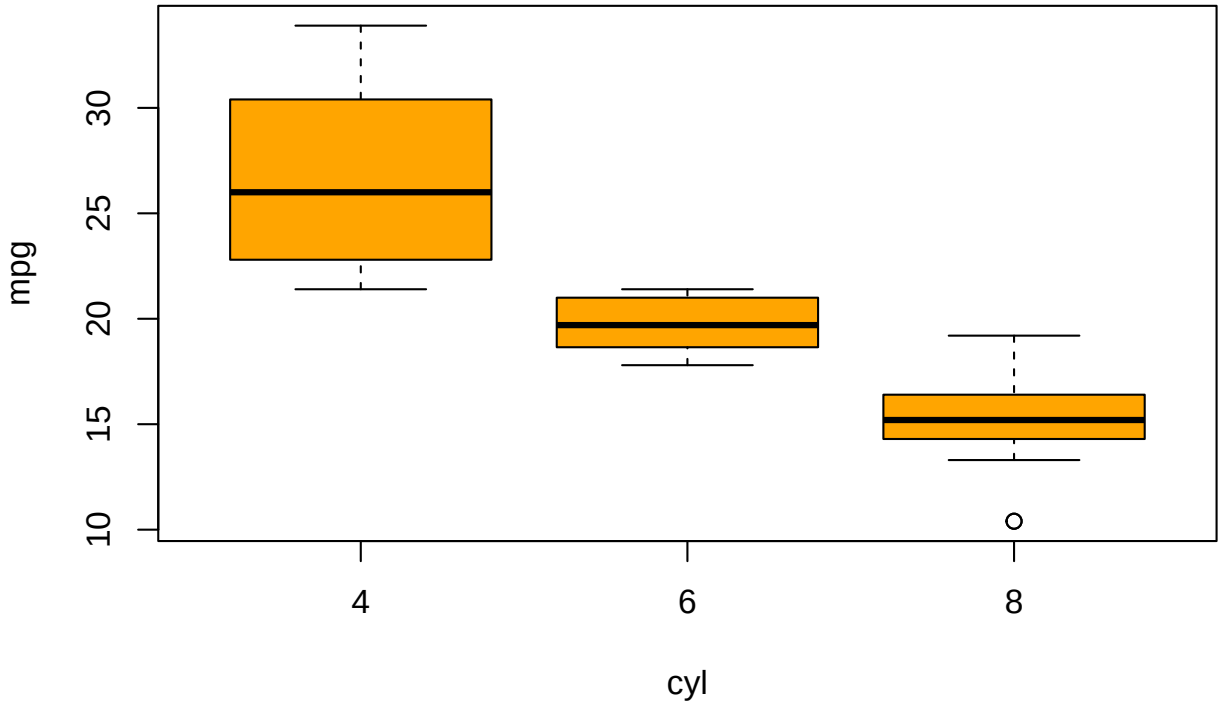

Figure 4: Fuel economy in cities, grouped by the number of cylinders.

B.2 Tables

Table 4: Descriptive statistics of ....

	3m	6m	1yr	2yr	3yr	5yr	7yr	10yr	12yr	15yr
Mean	3.138	3.191	3.307	3.544	3.756	4.093	4.354	4.621	4.741	4.878
Median	3.013	3.109	3.228	3.490	3.680	3.906	4.117	4.420	4.575	4.759
Min	1.984	1.950	1.956	2.010	2.240	2.615	2.850	3.120	3.250	3.395
Max	5.211	5.274	5.415	5.583	5.698	5.805	5.900	6.031	6.150	6.295
StD	0.915	0.919	0.935	0.910	0.876	0.825	0.803	0.776	0.768	0.762

Here is another variant of programming a table with LaTeXsyntax.

C Declaration of Authorship

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Mandy Mustermann