NEL VERHOEVEN

STATISTICS IN STEPS

Boom

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Statistics in Steps

For Roosmarijn & Guus

Statistics in Steps

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Boom

+ website!

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Preface

Telling people at parties and social gatherings that you are a "statistician" doesn't win you friends or make you popular. This is partly because people assume that stats are difficult and boring, and it's also because people think that stats are something that they are unlikely to come across in their daily lives.

Yet I still like telling people: "I'm a statistician!" I teach stats, and I think stats is fun and interesting to use. Why? Because I can analyze and interpret data to satisfy my insatiable curiosity and I can use stats to find answers to the interesting questions facing society. What's more, while you may not realize it, people use stats every day, they read about them in the papers, you see them used on television and the internet, and you apply them at work. Many students can't see the point of stats when they start out at university, yet often I get positive responses from people after a while, when they realize that they have benefited a great deal from the statistics courses they have followed.

Why is it that so many people dread having to learn about statistics? And more to the point ... how can we change this? That was pretty much the subject of my thesis, and four years of intensive research produced several recommendations on how to make statistics more "attractive." All very well, but how do you actually do that? By avoiding boring subjects (coming up with an alternative for "standard deviation"), getting on well with students during lectures, by giving them lots of support, explaining things at length and preferably doing away with exams? To be honest, I don't have the answers either. But what I have done with this book is to try and make stats a little more accessible and make things clearer. I hope I have managed to do so.

Most of you will be using this book because your study has prescribed it. I know how you feel: you're dreading the lectures, the difficult assignments, the SPSS exercises and particularly the exams. What I can do for you is take my experience with statistics and giving courses to beginners and advanced students and turn it into a clear and useful text. I have been involved with procedure and statistical education since the nineties, not only as a designer and author, but also as a lecturer. Throughout the years, my students have been the ones who have inspired me and encouraged me to take stats out of its boring, difficult academic ivory tower and make them more accessible for a wider audience. Statistics are not confined to a particular time, or to particular people.

Over the years, I have gathered many examples of statistical techniques, I've looked critically at the explanations for distributions, transformations and tests, and from these I have chosen the best based on my own experience and the learning objectives that colleges set for their students. Statistics are a means to an end, not an end in themselves. Statistics should be used to organize

information, to present good results and to make them usable for society in general. So statistics are a tool.
Writing a book like this and having it translated it into English is not something you do all on your own. For that reason, I would like to thank a few people who helped me. First and foremost, Barbara Reed for translating the Dutch version into English, and Esther den Hollander for sharing ideas, helping me to think things through, editing and commenting during the process of translating the Dutch version of the book into this English version.
Furthermore, I'd like to thank Marjolijn Voogel and Gerdi Smit for giving me the moral and logistic support from the publishing house I needed during the writing process. I'm also indebted to Metha Kamminga and Melanie Bothof, who read the Dutch version of the book closely and provided comments and advice on mathematical and statistical matters.

I dedicate this book to the future generation who will be confronted by statistics much more so than is now the case. The fact is that information flows are accelerating, and figures are playing an increasingly important role in all kinds of processes. Statistics, with all its rules and conditions, is indispensable to this. In twenty years' time, students will still have to learn about statistics. I hope that this book contributes to clear explanations and makes applying stats simpler and, by doing so, makes the subject more appealing.

Nel Verhoeven
Ovezande, summer 2020

Contents

When do you use statistics?

The title for this introduction may seem strange. When do you use statistics? The answer is very straightforward: all the time actually! Our daily lives are full of stats:

- When you're standing in the queue at the till, you are constantly estimating how long you'll have to wait.
- When you calculate your final grade for Economics.
- When you check out the weather report in the paper in the morning and it says there's a 50% chance of rain.

Statistics, what is that actually?

The first question that presents itself is: what is *statistics* actually? Statistics is the science that concerns itself with gathering, processing, interpreting and presenting quantitative data. Actually, statistics spans all sciences because it's multidisciplinary. It bridges the various scientific disciplines because it is used in the social sciences as well as the arts, like linguistics for instance. It is a procedure that is used in all subjects; it is a tool to process information. It does this using graphs, tables and tests.

Statistics is about analyzing figures and numbers; it's about numerical information. First you have to collect the data. When do you that? Generally as part of a research project. In this introductory chapter, we discuss the place that statistics has in research projects. We show you when you use statistics and its role your research. Statistics can also refer to "statistics": a collective term for the presentation of numerical results (figures), and then it takes the plural form. But it boils down to the same thing.

The point of statistics

Statistics is not a popular subject, nor is it one of those courses that students generally look forward to. This partly because of the mandatory nature of the study material. The threshold for taking an extra course in stats or for applying them is often high. It is partly because many people can't see what the point of statistics is for their career or for society in general. That is a misconception. Contrary to what you'd expect, stats are used (virtually) every day: in the media, at work, and obviously during your study. Once you start using statistics to reach a goal, and not as an end in themselves, the threshold becomes much lower. Statistics should be used as an *instrument* to answer questions. It should mainly be used to organize information, to present good results and to make them usable for society in general.

In this book, I try to remove preconceptions about statistics. I do so by giving relevant, appealing and topical examples, ones that reflect the student's daily experiences, by explaining statistical techniques in a simple and clear way, and by offering exercise materials that can be used to practice these techniques. No long-winded technical diatribes about formulas, but simple and clear applications that can be used in practice.

Learning about statistics

If you decide to take a course in statistics anyway, then you must practice, practice, practice. You're fortunate if you can be part of a research project: plenty of opportunity to practice. If that is not the case, then I suggest working in groups as much as you can: a lecturer is not always to hand, and our experience shows that students are good at helping one another when it comes to doing assignments and studying difficult subject matter. And then there's the much-respected lecturer. Don't be afraid to ask questions, you're very unlikely to be the only one who doesn't understand something. So ask for an explanation if you need to.

Various kinds of statistics

You can use statistics in various ways:

- To organize and describe information: we refer to this as *descriptive* statistics.
- to calculate probability: *probability calculus* is a more theoretical kind of statistics that works out the likelihood of something happening based on a theoretical distribution.
- To test data and to apply the results more generally: we refer to this as *inferential* (inductive) statistics.

In this book, we begin with descriptive statistics, we go on to discuss the basic principles of probability theory, and finally we shed light on inferential statistics.

In this book and on the accompanying website, experience with statistics and giving courses to beginners and advanced students are combined and turned into a clear and useful text. Over the years, many examples of statistical techniques have been gathered, the explanations for distributions, transformations and tests have been studied critically, and from these the best have been chosen, based on experience and the learning objectives in the curricula at colleges and universities.

In virtually every chapter that follows, we will be using formulas, but only where it is necessary. If it's not necessary, we've left them out. In other words: *as little as possible but as much as is necessary.* And guess what? The number of formulas you need to get acquainted with statistics in this book fits on less than four A4 pages. So it's not that bad after all!

Objective

The primary objective of *Statistics in Steps* is to give you as a student all the necessary tools that you can use to analyze information (data). It includes an introduction to the statistical methodologies used in data analysis. The aim is that you learn to use these statistical instruments when processing data quantitatively. *Statistics in Steps* can serve as a textbook, but also as a reference work when you have to process quantitative information.

Another important objective is to familiarize you with statistics. The book and the website have been structured in such a way that a logical explanation is given about how a certain technique works, and for which research questions that technique can be applied. The emphasis is not so much on the formulas behind the techniques (although we do explain them). Instead it is on how these formulas are applied. Finally, the intention is to offer the information just in time, and just enough of it. That is to say: the right level of explanation and the right amount of information at the right time.

This method is suitable for students at colleges and universities, and it serves as a reference work for those of us who are looking to process quantitative research information.

Structure of the book

Before the "difficult" statistics begin, you need to know what place statistics has in research projects: when to use statistics and how they relate to the rest of your research. This is what Chapter 1 is about. This is where we focus on various basic concepts: *design*, *data collection*, *analysis* and *evaluation*. We show you when and how you can apply statistics, and how to present the findings. This short summary of the phases is based on the *Doing Research* procedure, a book published previously in this series.

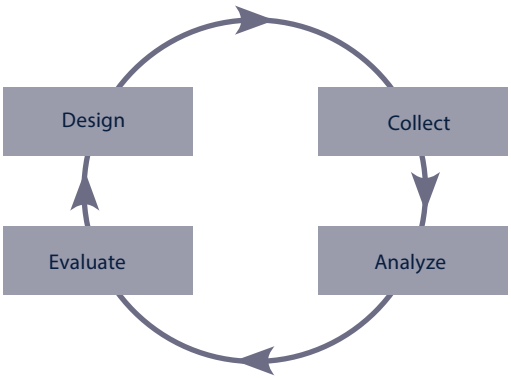

Figure 1 The research cycle showing the research phases

After discussing a few basic concepts, we arrive at descriptive statistics. In Chapter 2, we discuss measurement levels, measures of central tendency and variability, figures and tables. Where necessary, we go into the study material in greater detail, for instance the roles that observations or properties of distribution play. We start with descriptions of one variable at a time, i.e. univariate statistics. After that, we discuss descriptive statistics based on two variables, i.e. the bivariate type (Chapter 3). This involves graphs of two variables and cross tabulations.

We can't escape it here either: we've got to discuss probability theory, point and interval estimation, hypothesis testing, significance and test results. But we'll do it step by step in Chapters 4 and 5. We'll first talk about the probability distributions that we need to be able to understand testing. After that, point and interval estimates are discussed in Chapter 5. The focus then shifts to inferential statistics: we explain what hypotheses are, why they are necessary and how you approach "significance." Chapter 5 is rounded off with a procedure for conducting tests, the *W8 procedure*.

Significance

The term "significance" has been bandied about a lot recently: to lay down policies, sell merchandise ("really" significant improvements ... not really actually), and to persuade people in other respects. Take, for instance, the advert about a well-known washing powder that offers "significantly better results that its competitors." It is important to check what that term means, how you should approach it and which alternative interpretations there may be, because obviously there are others, especially when it comes to the nuances in the interpretation that you may feed back to policymakers.

We do that in Chapter 5. Concepts like the quality of an effect, the strength of the correlations, the power and errors of both the first and the second kind are then discussed. Unfortunately these errors have led to misconceptions and mistakes in interpretation, and (worse still) to the wrong decisions being made and the wrong measures being taken. Where are the real statisticians when you need them?

Various types of tests are also dealt with in this procedure, derived from the learning objectives in the curricula at colleges and universities. Chapter 6 deals with the differences between two populations. These are the so-called z and t tests, for paired and independent group means. The test for one mean is also explained. Correlation and regression analysis are discussed in Chapter 7: the analysis of the links between two variables and how to interpret the possible effects. Chapter 8 gives a more extensive treatment of "variance tests": analysis of variance, also called ANOVA, assesses the differences between more than two groups. To deal with the growing stream of variables at a low measurement level (so-called "qualitative variables") we end by discussing a few non-parametric,

i.e. distribution-free, alternatives for correlation and variance tests (Chapter 9). We use non-parametric tests to assess the differences between groups, without the conditions for the measurement levels and distribution being met.

But, as previously stated, we start with a brief overview (in Chapter 1) of the research phases involved, and then we go on to discuss a few key concepts.

Reader's guide

If you are a beginner when it comes to stats, then the best thing to do would be to work through the book from start to finish, and to do the exercises along the way. Discussing things with fellow students or researchers in the process is highly advisable. If you've got a bit of experience with quantitative analysis, then this teaching method may serve you well as a reference work. You can use the various chapters or the extensive index for this.

Tools

To make learning easier, we offer you a range of tools in this book, namely:

- *Learning objectives*: learning objectives are given at the beginning of each chapter.
- *Checkpoints*: each subject ends with a few questions that you can use to check whether you have properly understood what's been taught.
- Apart from theory, several *examples* of the subject under discussion are given.
- *Formulas* are not merely presented; they are explained in great detail.
- The book also contains a summarizing *overview of all the formulas used*, brought together in a handy list on the inside of the book's cover.
- The appendix at the back of the book presents four probability distribution tables.
- *Assignments*: at the end of every chapter there are assignments so that you can practice the procedures, the techniques and interpreting the results. Unless otherwise stated, the data used for these assignments is not derived from data actually collected. We mention the source if we have used existing results.
- The following material is available on the **www.statisticsinsteps.nl** website.
  - the answers to the assignments;
  - the answers to the checkpoints;
  - an overview of common research terms and their definitions;
  - a mock exam with multiple choice questions;
  - information about SPSS.

The text will refer you to the website when it is necessary and useful. This is done using the icon shown on the right.

SPSS

Slowly but surely we'll be familiarizing you with SPSS software, with its commands, data fields and output windows. By the end of the book, you will at any rate be able to use SPSS for a range of simple analyses.

All the techniques in the book are also processed in SPSS. For the rest, there are SPSS examples for all statistical calculations. SPSS launches a new version every year. Versions 25 and 26 (for Mac and Windows) are used in this book. By the time this book is published, there is bound to be a new version. Our experience is that the changes are not major and that you will be able to rely on the manuals for earlier versions.

Finally

I have explained my commitment to keeping the explanations simple, to use a step-by-step procedure, to only offer information when and where it is necessary. For the rest, it was never the objective to write a "statistics bible" or a "statistics cookery book." Confusing, because you would have thought that step-by-step analysis and the assumptions for your tests suggest otherwise. My objective is, however, to make statistics doable, memorable and easy to use. I hope to have succeeded in this effort. I will gladly address the issue in the next edition. If you discover any "gaps" in this book, please don't hesitate to let me know. I will gladly address the issue in the next edition.

Doing research 1

We mentioned in the introduction that this book is about analyzing quantitative data, i.e. it's about statistics. Generally speaking, you'll be doing the analysis during the third phase of your research project: the analysis phase. This means that statistics is only *part* of the research project as a whole. You've already designed the research, collected data and part of your report is already finished.

In this first chapter, we'll be discussing all the phases of quantitative research projects in brief. Besides a description of what each phase entails, we provide an overview of the common research terms used in each phase. There is also case material that will be discussed in greater detail for each phase. If you haven't started your research yet, and you open this book on the first page, then you will in any event become familiar with research jargon. You will also find out when statistical analyses are pertinent during the project. Finally you'll become familiar with the world of data collection and reporting. If you would like to find out more about how research is carried out, then the reader's guide that has been included will be a great support. If you want detailed information on how to set up and carry out a research project, please refer to *Doing Research*, an introductory textbook that guides you through the whole process of doing applied research (Verhoeven, 2018).

Learning objectives

By the end of this chapter you will be familiar with:
- the phases of applied research;
- several commonly used concepts;
- what design, data collection, analysis and reporting entails.

1.1 Phase 1 – The design phase of research

Let's consider for a moment where a research project begins. When you initially design your research project, there is a lot that you have to take into consideration. You have to demarcate the subject, you have to draft the central question and objective, prepare a proposal for the gathering of data, prepare a proposal for the analysis and set out a *timeline* that you will be able to meet. Oh dear! That is no easy feat.

Example Food truck festival 1

Recently, so-called food truck festivals have become very popular. Food truck festivals are small gatherings where all kinds of dishes are offered from several mobile kitchens (often in converted vans and caravans), for example in a park. All of this happens with music playing in the background. These festivals often don't charge an entry fee. Suppose you are doing research into how people perceive these festivals, and what their opinion is of them.

You set up your research project during the design phase. You do this in consultation with your study supervisor or with your client. If you are doing research on your own, it would be a good idea to discuss the design with someone. Put simply, you research starts out like this:

a. There is a *reason* for your research: a medical researcher is looking to run trials on a new medication; there are issues in a suburb that require research; policy measures need to be developed; a product concept needs to be tested; a new market needs to be explored. These are just a few examples.
b. There is a question or an issue; based on this you define the *central question and an objective*. Together they constitute the problem description of your project. The objective is twofold: you indicate how the client intends to use the results, and you describe the research objectives.
c. You demarcate your subject properly: what is part of the problem, and what is not. What definitions do you use? Are there any previous research results on the subject? What theoretical models can you use? You do this by carrying out preliminary research.
d. You draft a plan for conducting the research, including:
   - the background and the central question;
   - a proposal for the data collection method, the time during which the data will be collected (fieldwork) and the population;
   - a proposal for the analysis
   - an overview of anticipated situations that may affect the reliability/validity;
   - a timeline.

It is essential to discuss the final design with your client and/or supervisor, and that you agree precisely what you will be doing and when you'll be doing it, and also what you won't be doing. You may have to stick to a *research budget*. This involves being given money to carry out your research (the researchers are paid to do the research) or to cover your costs, for instance for the laboratory, printing the questionnaires or travel expenses.

Research log

Here's a tip to round off this section: keep a *research log* in which you keep notes about your research. A research log can be extremely useful in all of the research phases: you can note down times when you made decision, you

can record meeting reports, you can jot things down, and so on. Logbooks prove their worth during the analysis phase: you can make a note of the steps in the analysis, you can do interim calculations, you can write down your interpretations, and make notes about the progress of your analysis.

You could use a notepad for your research log, but Excel, Access, OneNote and even Word are useful when it comes to keeping a research log. There are also digital tools that can be used to keep your research log up to date, like Evernote, Google Drive and iDrive. The advantage of these digital tools is that you can view the latest version of your notes on any of your devices. Should you decide to use a notepad, then mark the decisions with a colored sticky bookmarker, so that you can find them easily.

Example Food truck festival 2

The reason for the study into the perceptions of food truck festivals is that municipalities want to organize these festivals, but want to know whether what is on offer suits the visitor population. And that not only applies to the range of food and beverages on offer. They may, for instance, organize activities during the day for small children and their parents, and then hold events in the evenings for an adult festival audience. It's also important that the organization of the event goes smoothly and is harmonious, and that health and safety are safeguarded. For these reasons it would be good to involve the food truckers, the security personnel, the sponsors and other organizers in the research. The following question could serve as the central question: what perceptions do visitors and participants have of holding a food truck festival in their municipality in 2016?

The website statisticsinsteps.nl has a glossary that explains commonly used research term.

1.2 Phase 2 – Data collection

Now that you have prepared the design, you are ready for the second research phase: collecting data. There's a lot to be said on this subject, much more than can be summarized in one brief section. We will restrict ourselves to the main features: what does "data collection" entail, what are the main groups that you will be gathering data about, which types are suitable for statistical analysis?

What happens during the data collection phase? You may well be thinking that that speaks for itself. We collect data! But don't be fooled, there is much more to it than that.

First and foremost, there's a difference between qualitative and quantitative data collection: collecting numerical data and non-numerical data. Your choice about whether to use quantitative or qualitative data collection methods is

based on your central question. Then you decide exactly which method you will use: will it be a survey, an experiment, will you be conducting interviews, observing participants or doing literature research?

You then go on to make the concepts measurable. In other words, you come up with questions for the survey, an experimental approach, questions for interviews or an observation category. This is called *operationalization*. It is a difficult phase because you only have one opportunity to ask questions, and so you have to get it right first time. This is when you may be in danger of compromising the *construct validity*. You constantly ask yourself: am I measuring what I want to measure?

Finally, you proceed to actually collecting the data. Once again, it's decision time:
- Which *population* do I have in mind? (All being well, you would have included this in your research design.)
- Which *sample* am I going to draw? Will I be drawing a sample at all?
- How will I approach respondents?
- How can I make sure that I get the best possible *response rate*

Collecting quantitative or qualitative data

If you're looking to collect data from a large group of people, if the data to be collected is superficial, not of a sensitive nature or if you are researching people who are undergoing a specific treatment, you usually opt for a *quantitative method* of data collection. You won't be digging down to get in-depth information from your questions. You can measure someone's opinion superficially and quickly, and in a short space of time you'll have a lot of numerical information at your disposal. Which data collection methods do you have to choose from?
The main types of methodologies are:
- *surveys*: questionnaires for a large group of people;
- *experiments*: measuring the effect of a treatment or testing a specific outcome, in a laboratory (unbiased experiment) or in a natural environment (field experiment).
- *secondary analysis*: a re-analysis (based on a different question) of quantitative data collected previously for a different purpose.
- *real-time data*: a new, popular and growing type of data collection. Big data that is collected from mobile devices, GPS systems and the internet.

It may be that your central question is about backgrounds involving certain events or behavior, from the perspective of the people taking part. Or you're looking for more insight into the lifestyles or certain groups of people who live together, rather than purely numerical information. Or maybe you are looking for explanations for present circumstances based on events in the past. In all of these cases, a *qualitative methodology* would suit your purposes. The main types of qualitative methods are:

- *interviews*: a face-to-face interview with one person or group of people in which the focus is on perspectives of the person or group being studied;
- *observation*: the systematic *observation* of the behavior of one or more individuals, for example in their own social environment. There are various subtypes of observational research, for instance direct and indirect observation;
- *qualitative desk research*, for example, archive studies, secondary qualitative analysis of existing texts, content analysis, literature research, and so on.

Example Food truck festival 3

For the food truck festival, the researcher designed two methods of data collection: a survey among visitors and interviews with a few participating municipalities, food truckers and safety officers. He has decided to conduct a survey among the visitors because then he can interview a big group of people, and ask them quite a lot of questions. The data can then be analyzed quantitatively. He expects to gather more detailed information from the municipalities, food truckers and safety officers and that their opinions will be against a specific background. That is the reason why he has chosen in-depth interviews: he wants to get a lot of in-depth information from a relatively small group of people. So the design is quantitative as well as qualitative.

Quality aspects when designing your research

When you design your research project, you have to take the quality of the research into account. Broadly speaking, this involves two aspects:

- *reliability*, the extent to which your research contains random errors;
- *validity*, the extent to which your research contains systematic errors; this can be subdivided once again into:
  - *internal validity*: the extent to which it is possible to draw the right conclusions;
  - *external validity*: the extent to which your results are generalizable;
  - *construct validity*: the extent to which you are measuring what you want to measure.

These quality aspects play a very important role throughout your research project. You have to take them into account when you design your research, when you collect the data and when you analyze it, and you examine them retrospectively in your discussion and conclusion. We will be paying particular attention to them wherever necessary.

Population and sample

Before you start analyzing the data you have collected, it is important to know the difference between a population and a sample, and what the consequences are of drawing a particular sample for the statistical methods you choose and for your analysis results. Each time you make a decision, it has consequences.

The *population* is the domain of your research project. It encompasses all the units (people, cases, etc.) about whom you intend to make statements For instance, you may be researching the study results of medical students at Dutch universities, or analyzing the opinions of Facebook users, or researching people who own a BMW.

It is hardly ever possible to collect data from everyone in the population. Which is why most researchers opt to draw a sample which you can use to gather information about a section of the population. There are two ways to do this: by drawing a *non-probability* sample or a *random* (or probability) sample. For instance, you can draw a random sample from all registered medical students at Dutch universities, select a random sample from the BMW customer base, or ask your Facebook friends to participate in your research, but then it would be a non-probability sample.

When you draw a *probability sample*, you draw your sample randomly. All the people or units in your population have a calculable chance of ending up in the sample.
Random sampling methods include:
- *simple random sampling*: a simple sample of all units in the population;
- *stratified sampling*: the population consists of "strata," i.e. existing subpopulations. A random sample is drawn from each stratum;
- *systematic with a random starting point*: a starting point is selected randomly, and then every fifth or tenth person is chosen. This method is popular for research projects carried out in residential areas. The respondents are chosen based on their street numbers;
- *cluster sampling*: the population consists of clusters; a sample of clusters is drawn and these clusters are studied in their entirety, for instance certain classes in a school;
- *multi-staged sampling*: this is a combination of several sampling methods, generally based on a cluster.

If you use *non-probability sampling* you select people based on specific qualities, or because they meet certain conditions. Non-probability samples are also used if it is not possible to draw the sample randomly. Non-probability sampling methods include:
- *convenience sampling*: all those willing to participate may participate;
- *quota sampling*: you select the respondents based on their characteristics, for instance 50 men and 50 women;
- *snowball sampling*: you start with your own network and you ask people whether they know of anyone who would be prepared to take part in your research. That is how you extend your sample;
- *purposive sampling*: you interview people based on their specific experience or expertise, for instance for expert research.

- *self-selection sampling*: candidates for research can apply if they meet certain conditions. This is often the case in medical trials whereby test subjects have to meet certain physical entry requirements.

Why it was important that samples are random?

The objective of the research is to be able to make statements about the population based on the findings. If you only have access to a sample, i.e. a subset, then you have to make sure that it reflects important characteristics in this population; the sample therefore has to be *representative*. Only then can you *extrapolate* the results! Your chances of having a representative sample are greatest if you have selected the sample randomly.

But you still have to test the sample. We do this by analyzing the extent to which the sample is in line with the population. You only extrapolate the results if you are sure that the results are not due to the way the sample is structured.

When is an experiment "random"?

As a general rule, experiments are not based on random samples because the sample is not drawn as such. Test subjects sign up to the research of their own accord. But researchers obviously want to make sure that the findings of the experiment are valid. They do this as follows:

- Test subjects are selected based on certain characteristics or inclusion criteria.
- These test subjects are then assigned *randomly* to the various conditions of the experiment.
  This is known as *randomization*.

External validity is not an essential condition for experimental research. As opposed to this, internal validity does play a major role; randomization enhances internal validity.

Going into the field: data collection

If you want to ensure that you have a firm foundation for your analysis, then the data that you collect must be of a high standard. Generally, experimental information and survey datasets – and sometimes existing datasets – are used for statistical analysis. It's not really possible to play around with existing datasets because they were collected for a different purpose. What is crucial is that the data from your experiment or survey is sound. What exactly does that mean?

For *quantitative* data, this includes:

- the sample size must be sufficiently large to be reliable;
- there must not be too many missing values, because then the dataset is less representative, i.e. statistically generalizable;
- for good construct validity and reliability you need good questions and experimental instruments.

For *qualitative* data, this includes:
- properly trained and prepared interviewers;
- large and random samples are not necessary, but you need enough information for *theoretical generalizability*;
- good questions and the right observation categories enhance construct validity.

Example Food truck festival 4

The research among visitors and participants in the food truck festival consisted of a survey and several in-depth interviews. For the latter, the researcher drew a non-probability sample from among experts: two municipal representatives, two food truckers and two security experts. Students conducted the interviews for the survey. They interviewed an equal number of fifty men and women that may visit the festival. This is known as "quota sampling". The researcher knows that he cannot extrapolate his results. But it's not that important anyway: the festival manager is looking for an indication of what the visitors may think about the festival. In that case, not only is random sampling not necessary, it's not very useful either.

1.3 Phase 3 – Data analysis

This may seem a bit redundant: a whole book on statistical analysis plus a section on the subject in Chapter 1. Yet it is important to outline the place that stats have in the research project as a whole. That is why we want to list a few basic concepts before we get into the details.

Qualitative analysis proves that you can analyze data without crunching numbers. This analysis strategy is used in a wide range of disciplines, like anthropology, art history research, literature research, as well as when analyzing "sensitive" information, for instance when it concerns subjects that are difficult to discuss. For the sake of completeness, we will focus briefly on this here.

Quantitative analysis

Statistical methodologies are used for quantitative analysis. You draw up a summary of the data you collected, and you test several assumptions in such a way that you can draw a number of conclusions from this. This is no simple matter. Generally you'll be working with a sample. The aim here is to extrapolate (or generalize) the results to the population. Hypotheses are statistical assumptions about your population. First you have to decide which hypotheses you will test, then you describe the data, and finally you test your hypotheses. In other words, you determine the extent to which your findings are due to chance or can be attributed to actual differences or relationships in a population.

To be able to do these analyses you need to know what your data consists of. You can do this by describing the data (variables), by examining the distribution, by looking at the levels of your variables, and by checking whether your data is comprehensive. The "measurement level" determines the extent to which a particular statistical test can be applied. We will discuss this in Chapter 2.

A specific procedure applies to analyses. This will be discussed at length in the following chapters. To give you an idea, what follows is a taste of the analysis procedure:

1. Which *questions* are you going to answer with your analysis? Familiarize yourself with the data: how many "missing values" are there, what is their measurement level, what do the distributions look like, what is the mean and the dispersion, which value is most common, what is the median? You have to have an impression of your data to be able to draw up an analysis plan, i.e. the plan that uses the correct tests.
2. Which *hypotheses* (assumptions about the findings) will you be testing?
3. Which *tests* will you be applying? This is based on your familiarization exercise.
4. Which *conditions* have to be met?
5. What is the corresponding *significance level* (limit for drawing statistical conclusions)?
6. What are the test *results*?
7. What is the *probability* that your assumptions will be met?
8. Will be your hypothesis be *rejected* or not? What is your interpretation in "simple English"?

Qualitative analysis

Often you want more background and not merely a "rating" ("to measure is to know"), and you also want to explore respondents' perceptions, not just the bare figures. This is when qualitative analysis plays an important role. We would argue in favor of collecting qualitative data alongside quantitative data, i.e. use *triangulation* (using several methods to answer your questions). This widens the scope of the research and, apart from statistical generalization, it means we can aim for theoretical generalization.

Example Food truck festival 5

The analysis for the data collected at the food truck festival consists of the following:

- Quantitative results are analyzed using SPSS; tables and graphs are created and responses from male visitors are compared with those of the female visitors.
- The qualitative data is analyzed using a method that groups terms together, i.e. summarizes them, for each section of the text. All the terms found are sorted, links between the terms are found, and finally a diagram of the findings is produced.

1.4 Phase 4 – Evaluating and reporting on your results

During the last part of your research, you write down your conclusions and discuss the results. This is also the phase during which you write the research report, in which you account for the methods used and interpret your results. This is when you address the quality of the results, when you discuss the reliability and the validity of the results. Finally, you discuss any limitations that your research may have, and you put forward recommendations.

In this section we explain how to compile a research report and how to discuss the results, mainly in the context of reliability and validity. At the same time, we shed light on a few basic concepts.

Structure of your research report

Figure 1.1 shows the standard format for a research report. It doesn't have a *table of contents*. That is because a lot of research reports are published as articles. Of course, you can always add a table of contents to make things easier for the reader. The table of contents follows directly after the synopsis, but before the introduction.

Title page
Summary
Introduction
Method section
Results
Conclusion and discussion
References
Appendices

Figure 1.1 Sections of a research report

Title page

This page contains the title and subtitle (if there is one), your name, date and place, your supervisor's name, the college or institute where the research was carried out. The client (if there is one) is not mentioned here.

Summary

This is the hard part. In about 250 words, you describe what the research was about, how the data was collected and analyzed, and what the main conclusion is. You may wish to thank people who helped you with your research project. For this, you write a separate *preface*.

Introduction

In this part of your report you set out the background (reason) for your research and the problem and objective. If you are conducting empirical research, this

is where you outline your theoretical set-up, the literature study that is the basis for your research, or you mention the results of previous studies. You also demarcate the terms, list definitions and formulate theoretical assumptions.

Method section

This is an important part of your research report, because you give an account of the methods you used for your research and its operationalization. It is also the most structured part, and it is divided into several subsections: population and sample, design and data collection method, operationalization (measurement instruments) and analysis procedure. You describe the domain, which data collection method you used and why, how you arrived at your measurement instrument (i.e. the questions in your survey, the observation categories or the experimental conditions in your experiment), and which statistical or qualitative analyses you carried out.

Results

This is where all the results of your analyses are presented. That is to say you present all the figures (quantitative research), or the findings of your qualitative analysis. If you are doing statistical analyses, this is where you mention which hypotheses were rejected and why, how strong the correlations are, what differences and similarities you found and what they entail. These matters are accompanied by tables and figures. We recommend that you put the main figures and tables in the main text, and all other tables and figures in the appendices.

Conclusion and discussion

In the fourth part of your report, you discuss the answer to the central question. This might look like a summary of your results, but it is better to write the conclusion in your own words. Repeating the results in an abbreviated form will not win you any prizes, and also you're not meant to repeat numerical information here. You've already done that at length in the results section.

Apart from answering your central question, you give your interpretation and you discuss the findings. The opportunities that you had to learn from your research are discussed here, and you also discuss the validity and reliability of the research, any criticisms that you may have and perhaps a discussion of any relevant or recent developments (mentioning the source of course). If you carried out the research on behalf of a client, this is where you put forward any recommendations you may have.

References

All sources that you used are listed in alphabetical order in the references. Obviously they are cited in the text where relevant. The *APA* guidelines, i.e. the American Psychological Association's guidelines, 6th edition, are used for many manuscripts.

Appendix

You put all the other material, a copy of your invitation letter to respondents, a copy of the questionnaire or the topics for discussion, additional figures and tables in the appendices. You number the appendices and give them a title so that you can refer to them in the main text.

Reader's guide to Doing Research

In this chapter we have barely touched on the subject of how to design and conduct research. If you would like to know more about the subject, then we recommend reading *Doing Research*, a textbook that is part of this series. In Chapters 2 to 6 of that book you will find detailed information about research design, designing questionnaires, demarcating the research and preliminary research. Chapters 7 to 12 discuss all the ins and outs of data collection methods. Chapters 13 to 16 contain all the information you need so that you can analyze your data, and Chapters 17 to 20 deal extensively with the steps you take during the fourth phase. The book also gives you various writing tips.

On with statistics

In this chapter we give a summary of a research project, the phases that the project consists of and the main points of attention during the research. Needless to say, this summary is far from complete. It merely gives an impression of the way in which research is set up. The rest of the book is dedicated to statistics, the quantitative variety, which is part of the third phase of a research project.