Statistical Methods – JoHo Practice Questions

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Chapter 1: Introduction – Questions

1. What is the difference between an independent and a dependent variable? Describe both terms.

2. Study both definitions of the term performance-motivation, as given below.

I. Someone gets assigned the task to build a tower of matches. Performance-motivation refers to the number of attempts someone tries, before he or she quits.
II. Performance-motivation is the ability to set yourself to do a certain performance.

Are these definitions conceptual or operational?

3. What does ‘correlational research’ mean?

4. A researcher wants to examine to what extent giftedness of children at secondary school coincides with behavioral problems in the class. What kind of research is suitable to examine this question?

5. What is the form of statistics called, that focuses on drawing conclusions?

6. Someone claims about a certain variable that the score of Elise is twice as large als the score of Adriaan. Which level of measurement should the variable at least have to be able to make certain claims?

7. In a study, the variable intelligence is measured as:

1 = IQ below 70
2 = IQ between 71 and 90
3 = IQ between 91 and 110
4 = IQ between 111 and 120
5 = IQ higher than 120

Which level of measurement does this variable hold?

8. In a study, the connection between gender, age and cognitive abilities is examined. Which of these variables can exclusively play a role as independent variable in psychological research?

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Chapter 1: Introduction – Answers

1. What is the difference between an independent and a dependent variable? Describe both terms.
An independent variable is a variable that is being manipulated by the researcher. Often, this exists of two conditions to which the participants are exposed. The dependent variable is a variable that is observed, after the independent variable is manipulated.

2. Study both definitions of the term performance-motivation, as given below.

I. Someone gets assigned the task to build a tower of matches. Performance-motivation refers to the number of attempts someone tries, before he or she quits.
II. Performance-motivation is the ability to set yourself to do a certain performance.

Are these definitions conceptual or operational?
Definition I is operational.
Definition II is conceptual.

3. What does ‘correlational research’ mean?
With this type of study, the association between variables is studied. With correlational studies, no claims can be made about cause-and-effect relationships.

4. A researcher wants to examine to what extent giftedness of children at secondary school coincides with behavioral problems in the class. What kind of research is suitable to examine this question?
Correlational research

5. What is the form of statistics called, that focuses on drawing conclusions?
Inferential statistics.
This method assumes that the independent variable has had a certain effect, if the difference between the means of the conditions is larger than expected based upon coincidence only. Therefore, we compare group means that we found with group means that we would have expected if there would only be some error variance. Unfortunately, this method does not provide certainty. Only a chance can be determined, which implies that the differences in group means are the result of error variance.

6. Someone claims about a certain variable that the score of Elise is twice as large als the score of Adriaan. Which level of measurement should the variable at least have to be able to make certain claims?
Ratio

7. In a study, the variable intelligence is measured as:

1 = IQ below 70
2 = IQ between 71 and 90
3 = IQ between 91 and 110
4 = IQ between 111 and 120
5 = IQ higher than 120

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Which level of measurement does this variable hold?
Ordinal

8. In a study, the connection between gender, age and cognitive abilities is examined. Which of these variables can exclusively play a role as independent variable in psychological research?
Gender and age

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Chapter 2: Data: distributions, connections and gathering – Questions

1. What are the three conditions (provisions) for causality?

2. Immediately after the exam M&T, we determined of 11 randomly chosen students how many of the 40 questions they answered correctly. The results are presented in the stemplot below.

0	2	6	6	
1	0	8	9	
2	1			
3	4	6	8	9

Determine the median.

3. What is the median of the scores 4-6-8-10-18?

4. What is the median of the following numbers: 8, 9, 14, 15?

5. The following five terms are used frequently to summarize the characteristics of a statistical variable: minimum, maximum, first quartile, third quartile, median. What is the right order, from small to large?

6. What does ‘error variance’ mean?

7. How can the standard deviation be computed from the variance?

8. To provide insight in the association between number of cigarettes smoked per day and the time needed to run 2 kilometers, you make a chart based on the data for a number of participants. Which variable do you put on the x-axis?

Chapter 2: Data: distributions, connections and gathering – Questions

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1. What are the three conditions (provisions) for causality?
   - *The variables should covary together*
   - *The cause should precede the consequence*
   - *The influence of other variables should be eliminated*

2. Immediately after the exam M&T, we determined of 11 randomly chosen students how many of the 40 questions they answered correctly. The results are presented in the stemplot below.

0	2 6 6
1	0 8 9
2	1
3	4 6 8 9

Determine the median.
19

3. What is the median of the scores 4-6-8-10-18?
8

4. What is the median of the following numbers: 8, 9, 14, 15?
11.5

5. The following five terms are used frequently to summarize the characteristics of a statistical variable: minimum, maximum, first quartile, third quartile, median. What is the right order, from small to large?
Minimum, first quartile, median, third quartile, maximum

6. What does ‘error variance’ mean?
Error variance is the variance that can not be explained by the researcher, and thus is caused by measurement error and variables that are not examined by the researcher.

7. How can the standard deviation be computed from the variance?
By taking the square root of the variance.

8. To provide insight in the association between number of cigarettes smoked per day and the time needed to run 2 kilometers, you make a chart based on the data for a number of participants. Which variable do you put on the x-axis?
The independent or exploratory variable is put on the x-axis, and the dependent variable is put on the y-axis. The number of smoked cigarettes is the exploratory variable here: you want to know if (and how) this influences the condition of smokers.

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Chapter 3: Reliability and validity – Questions

1. What is the difference between reliability and validity, two central terms within statistics?

2. Of which two parts consists the total variance in a data set of scores?

3. Between which two numbers does reliability range?

4. Which three kinds of reliability can be distinguished?

5. How can the split-half reliability be computed?

6. What is the difference between internal and external validity?

7. A study-counselor tries to predict study success. He administers a questionnaire about motivation to first year students. At the end of the year, he determines whether the students finished their year successfully. Next, he determines the correlation with the score on the questionnaire. What kind of validity is involved here?

8. A researcher has established that higher levels of testosterone in young men coincides with increased risk behavior when driving. In a follow-up study, he finds the same association for young women. What kind of validity is involved here?

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Chapter 3: Reliability and validity – Answers

1. What is the difference between reliability and validity, two central terms within statistics?
The reliability refers to the extent to which a measurement instrument provides consistent results. A reliable instrument will provide similarly results when doing a measurement twice. Validity describes whether the measured construct is indeed measured by the instrument.

2. Of which two parts consists the total variance in a data set of scores?
The total variance consists of the variance from the true scores and the variance from measurement errors (error variance and systematic variance).

3. Between which two numbers does reliability range?
Between 0 and 1.

4. Which three kinds of reliability can be distinguished?
- *Split-half reliability*
- *Inter-item reliability*
- *Inter-rater reliability*

5. How can the split-half reliability be computed?
For the split-half reliability, the items are divided between two sets. Next, a total score is calculated for each set. Then, the correlation between both sets is computed. If the items in both sets measure the same construct, the correlation between the sets should be high.

6. What is the difference between internal and external validity?
Internal validity implies that the researcher draws conclusions about the effects of the independent variable. External validity refers to the extent to which the results can be generalized to other conditions or samples than in the study.

7. A study-counselor tries to predict study success. He administers a questionnaire about motivation to first year students. At the end of the year, he determines whether the students finished their year successfully. Next, he determines the correlation with the score on the questionnaire. What kind of validity is involved here?
Predictive criterion validity.
We speak of predictive criterion validity, when a measurement instrument is able to distinguish between people on a behavior criterion in the future, thus, whether the measurement can predict well. This is especially important in the educational setting.

8. A researcher has established that higher levels of testosterone in young men coincides with increased risk behavior when driving. In a follow-up study, he finds the same association for young women. What kind of validity is involved here?
External validity. External validity refers to the extent to which found study results can be generalized to other samples.

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Chapter 4: Distributions – Questions

1. What are the mean and the standard deviation of a standard normal distribution?

2. Describe what a z-score of 3 means.

3. Someone chooses four marbles blindfolded. Half of them are red, the other half are green. What is the chance that he draws four green marbles?

4. In an a-select sample of 20 first year students in Leiden, it appears that 12 are living at home. What is the 95%-confidence interval?

5. What is the critical z-value that one uses when determining a 92% confidence interval for the mean?

6. It is being said that 55% of the marriages in New York ends in a divorce within fifteen years. Fifteen years ago, a large study has been started in which hundreds of married couples in New York are ensued. Imagine that we randomly draw 100 of these marriages. What is the exact form of the sampling distribution for the number of marriages that ends in a divorce?

7. A researcher examines the association between alcohol use and study results. Both variables have three response categories. Fifteen participants are examined, and the researcher finds a Cho-square value of 1.3. How many degrees of freedom are required for the test?

8. To test if there is an association between gender and smoking marihuana (yes/no), you count the number of smokers and non-smokers in a group of 75 men and 69 women. Next, you compute the Chi-square test. What is the number of degrees of freedom?

9. One would like to know if the ‘male/female’-distribution for employees differs between company A and B. Based on a sample, one determines that the proportion of men in company A is 0.40 and 0.52 in company B. In both cases, 100 participants are included. Test the null hypothesis with the Chi-square test. What value does the test statistic have?

10. A researcher examines whether the moment of birth influences if someone becomes a professional gymnast. In order to do so, the researcher selects 220 gymnasts who practiced gymnastic in the past 10 years. He determines the quarter in which they are born: 62 in the first quarter, 69 in the second, 40 in the third and 49 in the fourth quarter. Test the null hypothesis with the Chi-square test. What is the value of the test statistic?

11. What is the Kappa used for?

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12. In a study, it is examined whether the “extent to which children are sexually educated by their parents” differs for boys and girls. A hundred boys and a hundred girls of fifteen years of age and older are selected randomly. A Chi-square test is done, and gender and sexual education by parents appear to be associated with one another. The results are displayed in the table given below.

		Gender		
Sexual education by parents		Boys	Girls	Total
Not/a little	f_0 f_e	80 (67.5)	55 (67.5)	135
Extensively	f_0 f_e	20 (32.5)	45 (32.5)	65
Total		100	100	200

What is the value of the Chi-square statistic?

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Chapter 4: Distributions – Answers

1. What are the mean and the standard deviation of a standard normal distribution?
The mean is 0 and the standard deviation is 1.

2. Describe what a z-score of 3 means.
A z-score of 3 means that the score is 3 standard deviations away from the mean.

3. Someone chooses four marbles blindfolded. Half of them are red, the other half are green. What is the chance that he draws four green marbles?
0.0625

4. In an a-select sample of 20 first year students in Leiden, it appears that 12 are living at home. What is the 95%-confidence interval?
[*0.39; 0.78*]

5. What is the critical z-value that one uses when determining a 92% confidence interval for the mean?
1.75

6. It is being said that 55% of the marriages in New York ends in a divorce within fifteen years. Fifteen years ago, a large study has been started in which hundreds of married couples in New York are ensued. Imagine that we randomly draw 100 of these marriages. What is the exact form of the sampling distribution for the number of marriages that ends in a divorce?
The binomial distribution.
When a variable is measured with exactly two categories, the resulting data is called binomial. For instance, people are men or women. A coin can be tossed with either heads or tails above.

7. A researcher examines the association between alcohol use and study results. Both variables have three response categories. Fifteen participants are examined, and the researcher finds a Cho-square value of 1.3. How many degrees of freedom are required for the test?
4

8. To test if there is an association between gender and smoking marihuana (yes/no), you count the number of smokers and non-smokers in a group of 75 men and 69 women. Next, you compute the Chi-square test. What is the number of degrees of freedom?
1: The variable gender has two categories (male/female), the variable smoking also has two categories (yes/no). The number of degrees of freedom is then (2-1) x (2 – 1) = 1. To put it differently: four combinations are possible with the 2x2 categories: woman and smoker, woman and non-smoker, man and smoker, man and non-smoker. When you know the numbers of one of these four classes, the other classes are determined, because you know the number of man and women that participated in the study. Hence, the number of degrees of freedom is 1.

9. One would like to know if the 'male/female'-distribution for employees differs between company A and B. Based on a sample, one determines that the proportion of men in company A is 0.40 and 0.52 in company B. In both cases, 100 participants are included. Test the null hypothesis with the Chi-square test. What value does the test statistic have?
2.899
$X^2 = (40-46)^2/46 + (52-46)^2/46 + (60-54)_2/54 + (48-54)^2/54$
$X^2 = 36/46 + 46/46 + 36/54 + 36/54 = .782 + .782 + .667 + .667 = 2.889$

10. A researcher examines whether the moment of birth influences if someone becomes a professional gymnast. In order to do so, the researcher selects 220 gymnasts who practiced gymnastic in the past 10 years. He determines the quarter in which they are born: 62 in the first quarter, 69 in the second, 40 in the third and 49 in the fourth quarter. Test the null hypothesis with the Chi-square test. What is the value of the test statistic?
9.20

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11. What is the Kappa used for?
To measure the extent to which observers agree in their judgment.

12. In a study, it is examined whether the “extent to which children are sexually educated by their parents” differs for boys and girls. A hundred boys and a hundred girls of fifteen years of age and older are selected randomly. A Chi-square test is done, and gender and sexual education by parents appear to be associated with one another. The results are displayed in the table given below.

		Gender		
Sexual education by parents		Boys	Girls	Total
Not/a little	f_0	80	55	135
	f_e	(67.5)	(67.5)	
Extensively	f_0	20	45	65
	f_e	(32.5)	(32.5)	
Total		100	100	200

What is the value of the Chi-square statistic?
14.25

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Chapter 5: Samples – Questions

1. What is the difference between a parameter and a statistic?

2. Which three kinds of non-probability sample exist?

3. In a study about patients in psychiatric institutions in The Netherlands, a sample is drawn as follows: First, one draws at random a number of institutions from the full list of Dutch psychiatric institutions. Then, a number of patients is drawn at random from each of the selected institutions. What kind of sampling procedure is described here?

4. A researcher wants to know to what extent alcohol use is associated with study results. She puts a note on the bulletin board to ask students who drink to participate in the study. 33 students sign up. What kind of sampling procedure is described here?

5. What is meant with the so-called selection bias?

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Chapter 5: Samples – Answers

1. What is the difference between a parameter and a statistic?
A parameter refers to a value that describes the population. A statistic refers to a value that describes the sample.

2. Which three kinds of nonprobability sample exist?
- *Convenience sample*
- *Quota sample*
- *Purposive sample*

3. In a study about patients in psychiatric institutions in The Netherlands, a sample is drawn as follows: First, one draws at random a number of institutions from the full list of Dutch psychiatric institutions. Then, a number of patients is drawn at random from each of the selected institutions. What kind of sampling procedure is described here?
A cluster sample.
When it is difficult to receive information beforehand about how many and what kind of individuals are present n the population, cluster sampling is commonly used. In this case, the researcher does not draw individuals directly from the population, but from clusters of possible participants, such as regions within a country. Often, 'multistage sampling' is used with cluster sampling. With multistage sampling, one determines large clusters first. Then, smaller clusters within the large clusters are determined. This process continues until a sample is drawn, with participants randomly drawn from each cluster.

4. A researcher wants to know to what extent alcohol use is associated with study results. She puts a note on the bulletin board to ask students who drink to participate in the study. 33 students sign up. What kind of sampling procedure is described here?
A nonprobability sample (or convenience sample).
In some situations it is not possible or awkward to draw a chance-sample. In that case, a 'nonprobability' sample is drawn. With nonprobability samples, one does not know how representative the sample is for the population. Many psychological studies for example are performed on the basis of samples that may not be representative for the population.

5. What is meant with the so-called selection bias?
This implies that the way in which the participants are selected may lead to a biased image. Imagine for example online questionnaires. People who do not have access to the internet, are automatically excluded from the study.

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Chapter 6: Statistical inferences – Questions

1. In statistics, the term ‘significance’ occurs when testing hypotheses. Significance is given with a numeric value alpha. What does this value mean?

2. You want to examine whether the mean amount of euro’s students spend in the canteen in a certain week is less than 15. You collected data from a simple random sample of 25 students from the population of students who visit the Heymans canteen that week. On average, these 25 students spent 12 euros in the canteen. The standard deviation of de sample scores equals 2.22. Which hypotheses are tested here?

3. Considering the information of the above question: When do we reject the null hypothesis and assume the alternative hypothesis, when we test with a significance level of 5%?

4. A 95% confidence interval determines from a sample of size *n* that we are 95% certain that the population mean is within the boundaries of this interval. Is this statement true or false?

5. You take a sample of 4 digits from a large population with a mean of zero, and repeat take 100 times. This provides you with 100 sample means. You try to normalize the digits by dividing each digit by the standard deviation (the standard deviation of the 100 sample means). For each of the 100 digits, you calculate the standard error (SE) separately by dividing the standard deviation of the 4 digits in the sample by the square root of 4 (thus 2). Hence, you apply the rule: SE of the mean = SD/n^0.5. Now, you have 100 new digits, of which each digit is a different estimate of the SE. Which distribution for the sample means follows?

6. Five friends are going on a day trip to Paris. Everyone one pots 80 euros. The variance equals 36. Just before the friends leave, a sixth friend joins. However, he only brought 65 euros en pots these. What is the chance on 65 euros or less?

7. You are comparing the size of mussels in the sea by using a z-test. You find that the z-value equals 3.5. What is the most correct conclusion?

8. Data are collected of 500 children on Becks Depression Inventory (BDI). The scores appear to be normally distributed with $\mu = 105$ en $\sigma = 12$. What is the percentage of children with a BDI-score between 100 and 120?

9. Again, use the information from the previous question: N(105,12). One wants to help the 20% lowest scoring children with consultations at a school psychologist. What is the highest BDI score for children that will receive extra help?

10. A researcher wants to examine if the mean IQ of persons with a small head is larger than 100. The null hypothesis is rejected from a mean of 107.5 onwards. It is given that the IQ scores in the population are normally distributed with a standard deviation of 15; this applies to both the null hypothesis as the alternative hypothesis. The researcher collected data from a simple random sample of $n = 20$ persons from the population persons with a small head. The average IQ equals 91.

Which level of significance did the researcher use?

11. A career choice agency uses a normed IQ-test for HAVO-students from the highest grade. The test has a variance of 225. The scores, that are received from this test, are normally distributed. A sample of 25 students from the group that applied to the agency, scores on average 119. What is the 95% confidence interval for the population mean?

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12. The lifespan of energy-saving lamps is –according to the manufacturer- normally distributed with $\mu = 480$ en $\sigma = 50$. A person used 200 energy-saving lamps in his life, of which 20% had to be replaced within 400 hours. To see if he was lucky, he asks the manufacturer how many energy-saving lamps should have been ready to replace. The question is: how many energy-saving lamps should have been ready to replace, according to the manufacturer?

13. The variable weight in the population of bulimia patients under treatment is normally distributed with $\mu = 47$ en $\sigma^2 = 23.04$. What is the chance that the weight of an average person from this population is: $40 < \text{weight} < 50$?

14. The scores of a certain variable are normally distributed in the population with a standard deviation of 12. Imagine that there is a right-sided test and that the population mean is 80 for the null hypothesis. It is given that the null hypothesis is rejected from a sample mean of 82.5 onwards. What is the power, when the population mean is 86?

15. We compute the average grade for the course 'Introduction to Psychology'. The mean equals 6.5 with a standard deviation of 1.67. We assume that the grades are normally distributed. What is the percentage of students with a 7 or higher?

16. In a study with regard to the number of tips a child needs to solve a question, 165 children participate. These children are randomly allocated to one of the two groups: the first group receives training before the last measurement. The second group receives training after the last measurement. To compare these groups, an independent samples t-test is performed on the results of the last measurement. For the test, $\alpha = 0.05$ is used. In the SPSS output, we find the following values for Levene's test for equality of variances: sig. = 0.433 and for the t-test: sig (2-tailed) = 0.078. What can you conclude based on this information?

17. A person is judged and found guilty. After a few months, it turns out that this person is innocent and he or she is released. How is the mistake that is being made here, called?

18. The statistical power of a test to find a difference of at least 50% between the control group and treatment group in a certain experiment is 0.4. What does this mean?

19. The affinity with meat is being studied with a sample of 134 students. Before the study, half of the students were shown videos about the meat making process. The other half was shown a comedy movie. The mean of the first group equals 4.78 with a standard deviation of 1.61. The mean of the second group equals 4.54 with a mean of 1.56. Apply an appropriate t-test to this information. Can you reject the null hypothesis if you test one-sided with $\alpha = 0.05$?

20. A certain matched pairs t-test provides a significant result for a significance level of 5%. The power of this test at a reasonable effect size equals 0.12. What is the chance of wrongly rejecting the null hypothesis?

21. The time students need to solve an exam question is normally distributed with a mean of 30 seconds and a standard deviation of 3 seconds. You want to examine whether the mean time changes after practice. You randomly select nine students and let them practice the exam question for 30 minutes. Next, you assign them to a certain question and you measure the time X they need to solve this question. Assume the standard deviation remains 3. For which values of $\acute{x}$ do you reject the null hypothesis that μ remains 30 seconds, with a two-sided test with $\alpha = 0.01$?

22. A child psychologist from France examines a random sample of 25 French children. He applies this study, because a colleague from the United States claims that American children read books for 8.25 hours per week on average. The psychologist thinks that this mean is lower in France. Therefore, he asks how many hours the children from his sample read weekly. The

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sample mean appears to be 7 with a variance of 4.829. Can you reject the null hypothesis when you test left-sided with $\alpha = 0.05$?

23. A test is normed such that $\mu = 100$; the population variance is not known. In a sample of 31 boys and girls from the Sint Jozef primary school in Utrecht, we find that  = 103 and s = 6.28. We study the question whether the participants are part of a population with a mean higher than 100. Can we reject the null hypothesis with $\alpha = 0.05$?

24. The teacher statistics wants to examine whether students with SPSS skills receive higher grades for his course than students without SPSS skills. The teacher takes 10 students from each group, who two by two agree on prior education, gender, age (group a: no SPSS, group b: SPSS). A statistics test is given to both groups. This results in the following output:

pair	1	2	3	4	5	6	7	8	9	10
a	13	4	3	7	10	11	12	5	9	8
b	15	3	5	11	9	11	13	19	7	5

We examine H0: $\mu = 0$, with $\mu = \mu_a - \mu_b$. What is the value of the test statistic?

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Chapter 6: Statistical inferences – Answers

1. In statistics, the term 'significance' occurs when testing hypotheses. Significance is given with a numeric value alpha. What does this value mean?
The significance, denoted with alpha, is a preregistered (so before performing a statistical test) chance. For each statistical experiment, we receive a so-called test-statistic. This is a quantity that follows a certain chance distribution. The specific value of the test-statistic is determined by the sample. When the chance P on the value of your test-statistic or extremer is lower than alpha, we say that the outcome of your experiment is significant. (P is called the exceedance probability). The value of the test statistic lies in the so-called critical area, that is determined on the basis of the alpha.

2. You want to examine whether the mean amount of euro's students spend in the canteen in a certain week is less than 15. You collected data from a simple random sample of 25 students from the population of students who visit the Heymans canteen that week. On average, these 25 students spent 12 euros in the canteen. The standard deviation of de sample scores equals 2.22. What are the null hypothesis and alternative hypothesis here?
0: μ = 15 vs. : μ < 15

3. Considering the information of the above question: When do we reject the null hypothesis and assume the alternative hypothesis, when we test with a significance level of 5%?
15 – (2,046*2,22)/√25
Thus, the null hypothesis is rejected for mean sample values of 17.08 and lower.

4. A 95% confidence interval determines from a sample of size *n* that we are 95% certain that the population mean is within the boundaries of this interval. Is this statement true or false?
This statement is true: for the 95% confidence interval as determined from a specific sample, there is 95% certainty that the population distribution is within the boundaries of this interval. Considering all possible 95% confidence interval, determined from all possible samples with size n, 95% of these intervals will contain the population distribution.

5. You take a sample of 4 digits from a large population with a mean of zero, and repeat take 100 times. This provides you with 100 sample means. You try to normalize the digits by dividing each digit by the standard deviation (the standard deviation of the 100 sample means). For each of the 100 digits, you calculate the standard error (SE) separately by dividing the standard deviation of the 4 digits in the sample by the square root of 4 (thus 2). Hence, you apply the rule: SE of the mean = SD/n^0.5. Now, you have 100 new digits, of which each digit is a different estimate of the SE. Which distribution for the sample means follows?
A t-distribution. If you know the SD of the original values, then everything is normally distributed. The problem is however, that you do not know that. A sample has 4 digits and you base the estimation of the SD in the original sample on this. It may happen that your estimation is too low, if you coincidentally draw four low digits. Vice versa, it may happen that your estimation is too high, if you coincidentally draw four high digits. Therefore, the digits are not normally distributed after dividing them by the estimated standard deviations. There may be some outliers, and the tails are likely to be thicker. This is known as a t-distribution. If the sample size increases to 30+, you can estimate the SD in the original distribution rather well in a sample of 30 and this all does not longer play a (big) role. Then, the t-distribution looks more like a normal distribution.

6. Five friends are going on a day trip to Paris. Everyone one pots 80 euros. The variance equals 36. Just before the friends leave, a sixth friend joins. However, he only brought 65 euros en pots these. What is the chance on 65 euros or less?
0.0062

7. You are comparing the size of mussels in the sea by using a z-test. You find that the z-value equals 3.5. What is the most correct conclusion?

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Because a z-test is being used, you may assume that the sizes of the mussels are normally distributed and that the mean for the difference between the two groups is tested (the median is used for non-normal distributions). The exceedance probability for z = 3.5 equals 0.00023, and this is much smaller than 0.05; there is a significant difference in mean size of mussels between the two populations.

8. Data are collected of 500 children on Becks Depression Inventory (BDI). The scores appear to be normally distributed with μ = 105 en σ = 12. What is the percentage of children with a BDI-score between 100 and 120?
55.72%

9. Again, use the information from the previous question: N(105,12). One wants to help the 20% lowest scoring children with consultations at a school psychologist. What is the highest BDI score for children that will receive extra help?
94.92%

10. A researcher wants to examine if the mean IQ of persons with a small head is larger than 100. The null hypothesis is rejected from a mean of 107.5 onwards. It is given that the IQ scores in the population are normally distributed with a standard deviation of 15; this applies to both the null hypothesis as the alternative hypothesis. The researcher collected data from a simple random sample of n = 20 persons from the population persons with a small head. The average IQ equals 91.

Which level of significance did the researcher use?
0.0125

11. A career choice agency uses a normed IQ-test for HAVO-students from the highest grade. The test has a variance of 225. The scores, that are received from this test, are normally distributed. A sample of 25 students from the group that applied to the agency, scores on average 119. What is the 95% confidence interval for the population mean?
$133.12 \leq \mu \leq 124.88$

12. The lifespan of energy-saving lamps is –according to the manufacturer- normally distributed with μ = 480 en σ = 50. A person used 200 energy-saving lamps in his life, of which 20% had to be replaced within 400 hours. To see if he was lucky, he asks the manufacturer how many energy-saving lamps should have been broken. The question is: how many energy-saving lamps should have been broken, according to the manufacturer?
This man was unlucky, because –according to the manufacturer- only 11 energy saving lamps should have been broken after 400 hours.

13. The variable weight in the population of bulimia patients under treatment is normally distributed with μ = 47 en σ^2 = 23.04. What is the chance that the weight of an average person from this population is: 40 < weight < 50?
0.6636

14. The scores of a certain variable are normally distributed in the population with a standard deviation of 12. Imagine that there is a right-sided test and that the population mean is 80 for the null hypothesis. It is given that the null hypothesis is rejected from a sample mean of 82.5 onwards. What is the power, when the population mean is 86?
0.99

15. We compute the average grade for the course ‘Introduction to Psychology’. The mean equals 6.5 with a standard deviation of 1.67. We assume that the grades are normally distributed. What is the percentage of students with a 7 or higher?
38%

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16. In a study with regard to the number of tips a child needs to solve a question, 165 children participate. These children are randomly allocated to one of the two groups: the first group receives training before the last measurement. The second group receives training after the last measurement. To compare these groups, an independent samples t-test is performed on the results of the last measurement. For the test, α = 0.05 is used. In the SPSS output, we find the following values for Levene's test for equality of variances: sig. = 0.433 and for the t-test: sig (2-tailed) = 0.078. What can you conclude based on this information?
The groups stem from populations with equal variances. There is no significant difference between the two groups in the number of tips a child needs to solve a question.

17. A person is judged and found guilty. After a few months, it turns out that this person is innocent and he or she is released. How is the mistake that is being made here, called?
A type-I error has been made. This person is found guilty, while in fact he is not guilty. Our law system uses the idea of the null hypothesis: "Not guilty until proven differently".

18. The statistical power of a test to find a difference of at least 50% between the control group and treatment group in a certain experiment is 0.4. What does this mean?
It means that, if there is a true difference of 50%, the test will provide a significant result in 40% of the cases. The null hypothesis of this test is: there is no difference of less than 50% between the control group and the treatment group. The alternative hypothesis is: there is a difference of at least 50% between the groups. A power of 0.4 means that the chance of rejecting the null hypothesis, when the null hypothesis is indeed false, is 0.4. Thus, in 40% of the cases, the test will give a significant results (when indeed the null hypothesis is false).

19. The affinity with meat is being studied with a sample of 134 students. Before the study, half of the students were shown videos about the meat making process. The other half was shown a comedy movie. The mean of the first group equals 4.78 with a standard deviation of 1.61. The mean of the second group equals 4.54 with a mean of 1.56. Apply an appropriate t-test to this information. Can you reject the null hypothesis if you test one-sided with α = 0.05?
No, P > 0.05

20. A certain matched pairs t-test provides a significant result for a significance level of 5%. The power of this test at a reasonable effect size equals 0.12. What is the chance of wrongly rejecting the null hypothesis?

21. The time students need to solve an exam question is normally distributed with a mean of 30 seconds and a standard deviation of 3 seconds. You want to examine whether the mean time changes after practice. You randomly select nine students and let them practice the exam question for 30 minutes. Next, you assign them to a certain question and you measure the time X they need to solve this question. Assume the standard deviation remains 3. For which values of $\bar{X}$ do you reject the null hypothesis that μ remains 30 seconds, with a two-sided test with α = 0.01?
For all $\bar{X}$ values lower than 27.424 or higher than 32.576.

22. A child psychologist from France examines a random sample of 25 French children. He applies this study, because a colleague from the United States claims that American children read books for 8.25 hours per week on average. The psychologist thinks that this mean is lower in France. Therefore, he asks how many hours the children from his sample read weekly. The sample mean appears to be 7 with a variance of 4.829. Can you reject the null hypothesis when you test left-sided with α = 0.05?
Yes, P ≤ 0.01
1. Sample + unknown iσ= one-sample t-test
2. Hypothesis. H0: μ = 8.25 and Ha: μ < 8.25
3. Test statistic t = (x- μ) / (s/√η) = (7.00 – 8.25) / (2.197 / 5) = -2.84
4. Significance level α = 0.05 and t.05(24) left-sided = -1.711. So, the H0 is rejected when the t-value is lower than -1.711

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5. Statistical conclusion: t = -2.84 < -1.711 = t.05(24) so H0 is rejected.
Looking up the t-value of -2.84 in table D with df(24) provides 0.0005 ≤ p ≤ 0.005 (left-sided)

23. A test is normed such that μ = 100; the population variance is not known. In a sample of 31 boys and girls from the Sint Jozef primary school in Utrecht, we find that = 103 and *s* = 6.28. We study the question whether the participants are part of a population with a mean higher than 100. Can we reject the null hypothesis with = 0.05?
Yes, P ≤ 0.01
1. Hypothesis. H0: μ = 100 and Ha: μ > 100
2. Sampling distribution t with df = 31 – 1 = 30
3. Test statistic t = (x- μ) / (s/√η) = (103 – 100) / (6.28 / 5.568) = 2.66
4. Significance level α = 0.05 and t.05(30) = 1.697. So, the H0 is rejected when the t-value is higher than 1.697
5. Statistical conclusion: t = 2.66 > 1.697 = t.05(30) so H0 is rejected.
Looking up the t-value of 2.66 in table D with df(30) provides 0.005 ≤ p ≤ 0.01 (left-sided)

24. The teacher statistics wants to examine whether students with SPSS skills receive higher grades for his course than students without SPSS skills. The teacher takes 10 students from each group, who two by two agree on prior education, gender, age (group a: no SPSS, group b: SPSS). A statistics test is given to both groups. This results in the following output:

pair	1	2	3	4	5	6	7	8	9	10
a	13	4	3	7	10	11	12	5	9	8
b	15	3	5	11	9	11	13	19	7	5

We examine H0: μ = 0, with μ = μ_a - μ_b. What is the value of the test statistic?
-0.8182

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Chapter 7: Correlation, regression and linear regression – Questions

1. Which three characteristics of the association between X and Y are measured with the correlation?

2. Variables X and Y have a R^2 of 0.15. Does this imply a large, small or moderate correlation?

3. When is the phi-coefficient used?

4. A psychologist examined for 100 employees their blood pressure (X) and the amount of profit their company made (Y). The psychologist calculates the mean, variance and covariance. The mean of x = 80, the mean of y = 60, SX^2 = 25, SY^2 = 36 and the covariance = -15. What is the value of the correlation between X and Y?

5. A psychologist found that the driving speed (X in km/h) and the number of traffic accidents (Y per year) are related as: y = 1 + 0.05*x. It is given that Mr. de Vries drives with a speed of 160 km per hour. How many accidents will he make per year?

6. What does it mean when the slope of a standardized regression equation equals 0.6?

7. You determine the Spearman rank order correlation coefficient for three pairs of observations (x, y): (1, 1), (2, 2) and (3, 3). What happens with this correlation coefficient if you chance the last pair to (3, 25)?

8. A researcher calculates Spearman rank order correlation coefficient between length and confection size. Length is measured in centimeters, and the confection sizes are S, M, L, XL, XXL, XXXL. The researcher codes these sizes as 1, 2, 3, 4, 5, 8. Is this method correct?

9. The (Pearson) correlation coefficient between variables X and Y equals 0.7. What is the percentage of variability in Y that can be explained by X?

10. Which of the following two statements is correct:

I. To be able to conclude that there exists a cause-and-effect relationship between variables X and Y, the Pearson r between X and Y has to be positive.
II. To interpret Pearson r between two variables, a linear relationship is desired, not not necessary.

11. If we find that Pearson's r equals 80 between two numeric variables, while inspection of the scatter plot clearly shows that the relationship is curvilinear, then:

A. There is actually no connection, despite the found correlation.
B. There is probably a connection, but Pearson r is not the right tool to use
C. There are probably outliers
D. The two variables are probably not normally distributed

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Chapter 7: Correlation, regression and linear regression – Answers

1. Which three characteristics of the association between X and Y are measured with the correlation?
- The direction of the association
- The form of the association
- The extent of the association

2. Variables X and Y have a R^2 of 0.15. Does this imply a large, small or moderate correlation?
This is a moderate correlation

3. When is the phi-coefficient used?
When two variables are dichotomous

4. A psychologist examined for 100 employees their blood pressure (X) and the amount of profit their company made (Y). The psychologist calculates the mean, variance and covariance. The mean of x = 80, the mean of y = 60, SX^2 = 25, SY^2 = 36 and the covariance = -15. What is the value of the correlation between X and Y?
-0.50

5. A psychologist found that the driving speed (X in km/h) and the number of traffic accidents (Y per year) are related as: y = 1 + 0.05*x. It is given that Mr. de Vries drives with a speed of 160 km per hour. How many accidents will he make per year?
9

6. What does it mean when the slope of a standardized regression equation equals 0.6?
It means that the predicted value increases with 0.6 for each 1-point increase of X.

7. You determine the Spearman rank order correlation coefficient for three pairs of observations (x, y): (1, 1), (2, 2) and (3, 3). What happens with this correlation coefficient if you chance the last pair to (3, 25)?
The Spearman rank order correlation coefficient does not change, because the change of y=3 to y=25 does not influence the rank ordering.

8. A researcher calculates Spearman rank order correlation coefficient between length and confection size. Length is measured in centimeters, and the confection sizes are S, M, L, XL, XXL, XXXL. The researcher codes these sizes as 1, 2, 3, 4, 5, 8. Is this method correct?
Yes, this method is correct. The confection sizes are ordered according to size (small to large). The Spearman rank order correlation coefficient can be calculated by coding the confection sizes numerically from small to large. Which specific numbers are used does not matter for the rank order.

9. The (Pearson) correlation coefficient between variables X and Y equals 0.7. What is the percentage of variability in Y that can be explained by X?
49%
The percentage of variability in one variable that can be explained by the other variable equals the squared correlation coefficient x 100%.

10. Which of the following two statements is correct:

I. To be able to conclude that there exists a cause-and-effect relationship between variables X and Y, the Pearson r between X and Y has to be positive.
III. To interpret Pearson r between two variables, a linear relationship is desired, not not necessary.

Both statements are false.

11. If we find that Pearson's r equals 80 between two numeric variables, while inspection of the scatter plot clearly shows that the relationship is curvilinear, then:

A. There is actually no connection, despite the found correlation.
B. There is probably a connection, but Pearson r is not the right tool to use
C. There are probably outliers
D. The two variables are probably not normally distributed

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Chapter 8: Multiple regression – Questions

1. What is the difference between the Pearson correlation and the multiple correlation?

2. We calculated the adjusted R^2 for two models: Model 1 has an adjusted R^2 of 0.788 and model 2 has an adjusted R^2 of 0.793. Which model is the best model, based on these values?

3. In a model, two partial correlations are found with the dependent variable: rx1y = 0.6, rx2y = 0.4. The explained variance is 60%. How much variance is explained by both variables?

4. Given is the following SPSS table:

	Unstandardized coefficients		Standardized coefficients
	B	Std. Error	Beta
(Constant)	-18.534		
X1	7.890		0.673
X2	-3.980		-0.380

What is the standardized regression equation?

5. What does B mean in the table of the previous question?

6. Which statement about the assessment of individual predictors is true?
   A. Assessing individual predictors is useful when the model is not better than chance alone.
   B. To assess, both b-weights as beta-weights can be used.
   C. Beta-weights can be influenced by the variability of a variable, additional predictors and measurement errors.
   D. Assessing beta-weights and structure coefficient can be sufficient.

7. What are the assumptions for multiple regression?

8. In a regression analysis of data for 150 participants, the regression weight of X2 is not significant, but the correlation is nevertheless high: 0.6. Other information is provided as well: the correlation between X1 and Y = 0.8. The correlation between X1 and X2 = 0.8. What can be an explanation for this?
   A. There is an interaction-effect between X1 and X2
   B. The data will probably be non-linear
   C. X1 does not have a unique contribution
   D. X2 does not have a unique contribution

9. Which statement about (semi-)partial correlations is true?
   A. The partial correlations provide percentages of unique explained variance for the variable.
   B. The squared semi-partial correlation of X1 is computed by dividing the unique explained variance by the total variance of the dependent variable (both explained and unexplained).
   C. The squared partial correlation of X1 provides the percentage of variance that partially explains the dependent variable.
   D. De squared multiple correlation (R2) equals the sum of unique explained variances.

10. What is multicollinearity?

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11. Multicollinearity causes a *higher/lower* R^2 value and *is/is not* desirable when one tries to understand the interaction between variables.

A. Higher, is
B. Higher, is not
C. Lower, is
D. Lower, is not

12. When is there a moderation effect?

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Chapter 8: Multiple regression – Answers

1. What is the difference between the Pearson correlation and the multiple correlation?
The multiple correlation has a value between 0 and 1 and can not be negative. The Pearson correlation ranges from -1 to 1.

2. We calculated the adjusted R^2 for two models: Model 1 has an adjusted R^2 of 0.788 and model 2 has an adjusted R^2 of 0.793. Which model is the best model, based on these values?
Model 2, because that model has a higher R^2, which implies more explained variance. The adjusted R^2 is the multiple R^2 plus a "penalty" for the complexity of the model. We are looking for models that can best explain the data with the lowest number of exploratory variables (simplest model), and that is precisely what the adjusted R^2 is doing: this measurement prefers simpler models. Hence, we choose model 2, because the larger adjusted R^2 represent a better balance between the size of the variance of the rest-term and the complexity of the model. In addition: the adjusted R^2 = 1 – RSS / (n-d-1) TSS / (n-1). With RSS is the residual sum of squares and TSS is the total sum of squares (the sum of squares of the response variable). When the number of exploratory variables d increases, the fracture increases, and the adjusted R^2 decreases, which is the penalty for more complex models.

3. In a model, two partial correlations are found with the dependent variable: rx1y = 0.6, rx2y = 0.4. The explained variance is 60%. How much variance is explained by both variables?
8%

4. Given is the following SPSS table:

	Unstandardized coefficients		Standardized coefficients
	B	Std. Error	Beta
(Constant)	-18.534		
X1	7.890		0.673
X2	-3.980		-0.380

What is the standardized regression equation?
$Y = 0.673*X_1 – 0.380*X_2$

5. What does B mean in the table of the previous question?
When X1 increases with 1, Y will increase with 7.890.

6. Which statement about the assessment of individual predictors is true?
   A. Assessing individual predictors is useful when the model is not better than chance alone.
   B. To assess, both b-weights as beta-weights can be used.
   C. Beta-weights can be influenced by the variability of a variable, additional predictors and measurement errors.
   D. Assessing beta-weights and structure coefficient can be sufficient.

7. What are the assumptions for multiple regression?
   - *The dependent variable should be interval scaled*
   - *There should be a linear relation between the predictors and the dependent variable*
   - *The residuals should have (a) a normal distribution (b) equal variances for all values of the linear combinations of predictors (c) independent of each other*

8. In a regression analysis of data for 150 participants, the regression weight of X2 is not significant, but the correlation is nevertheless high: 0.6. Other information is provided as well: the correlation between X1 and Y = 0.8. The correlation between X1 and X2 = 0.8. What can be an explanation for this?
   A. There is an interaction-effect between X1 and X2

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B. The data will probably be non-linear
C. X1 does not have a unique contribution
D. X2 does not have a unique contribution

9. Which statement about (semi-)partial correlations is true?
A. The partial correlations provide percentages of unique explained variance for the variable.
B. The squared semi-partial correlation of X1 is computed by dividing the unique explained variance by the total variance of the dependent variable (both explained and unexplained).
C. The squared partial correlation of X1 provides the percentage of variance that partially explains the dependent variable.
D. De squared multiple correlation (R2) equals the sum of unique explained variances.

10. What is multicollinearity?
Multicollinearity refers to the phenomenon that two predictor variables correlate strongly with each other and hence measure the same to a large extent.

11. Multicollinearity causes a *higher/lower* R^2 value and *is/is not* desirable when one tries to understand the interaction between variables.
A. Higher, is
B. Higher, is not
C. Lower, is
D. Lower, is not

12. When is there a moderation effect?
When a third variable changes the relationship between the dependent and independent variable.

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Chapter 9: Logistic regression – Questions

1. When is a logistic regression used?

2. What kind of form does a logistic regression have?

3. With logistic regression, there is only an association between X and:
   A. The odds
   B. The chance to belong to group 1
   C. The log (odds) (logit)
   D. The odds ratio

4. In a logistic regression model, a dichotomous predictor has been included. X1 has a regression coefficient of 0.568. The model has a constant of -3.734. An individual has characteristic X1. What is the chance that he belongs to the target group?

5. A researcher wants to do a logistic regression analysis on data about having a depression or not for a sample of 150 participants. The predictive variables are interval scaled. The dependent variable is dichotomous. The researcher finds, among others, that some predictors correlate heavily with each other, that the predictors are linearly related to the log odds and that the errors are dependent upon each other. Is it wise to do a LRA here?

6. I. For dichotomous data, the presence of a characteristic is coded with 1, and coded with 0 when the characteristic is not present.
II. LRA aims to predict to which group an individual belongs by calculating the chance that an individual belongs to the response group.
   A. Only statement I is true
   B. Only statement II is true
   C. Both statements are true
   D. Both statements are false

7. How does one interpret a significant omnibus-test?

8. Which test can be used to assess a logistic regression model? Explain how this works.

9. How does one calculate the percentage of accurately classified cases (PAC)?

10. Given is the following classification table about whether an intervention has been successful in the study or not.

		Predicted		
		No success (0)	Success (1)	Percentage correct
Observed	No success (0)	60	30	A
	Success (1)	50	90	B

Which percentages are missing at A and B?

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Chapter 9: Logistic regression – Answers

1. When is a logistic regression used?
When there is a categorical dependent variable and a quantitative or dichotomous independent variable.

2. What kind of form does a logistic regression have?
A S-form

3. With logistic regression, there is only an association between X and:
   A. The odds
   B. The chance to belong to group 1
   C. The log (odds) (logit)
   D. The odds ratio

4. In a logistic regression model, a dichotomous predictor has been included. X1 has a regression coefficient of 0.568. The model has a constant of -3.734. An individual has characteristic X1. What is the chance that he belongs to the target group?
0.04

5. A researcher wants to do a logistic regression analysis on data about having a depression or not for a sample of 150 participants. The predictive variables are interval scaled. The dependent variable is dichotomous. The researcher finds, among others, that some predictors correlate heavily with each other, that the predictors are linearly related to the log odds and that the errors are dependent upon each other. Is it wise to do a LRA here?
No, there is multicollinearity. Thus, an assumption of the logistic regression analysis is violated and you should not do a logistic regression analysis.

6. I. For dichotomous data, the presence of a characteristic is coded with 1, and coded with 0 when the characteristic is not present.
II. LRA aims to predict to which group an individual belongs by calculating the chance that an individual belongs to the response group.

   A. Only statement I is true
   B. Only statement II is true
   C. Both statements are true
   D. Both statements are false

7. How does one interpret a significant omnibus-test?
The variances of the predictor are not distributed equally.

8. Which test can be used to assess a logistic regression model? Explain how this test works.
The -2LL test. This test examines whether the set of independent variables can predict the dependent variable better than can be done on chance alone. It is tested whether at least one predictor has a significant contribution, different from zero. The higher the -2LL, the less the model fits the data.

9. How does one calculate the percentage of accurately classified cases (PAC)?
Divide the number of correctly classified cases by the total number of classified cases.

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10. Given is the following classification table about whether an intervention has been successful in the study or not.

		Predicted		
		No success (0)	Success (1)	Percentage correct
Observed	No success (0)	60	30	A
	Success (1)	50	90	B

Which percentages are missing at A and B?
A = 66.7
B = 64.3

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Chapter 10: ANOVA: One-way Analysis of Variance – Questions

1. What is an advantage of ANOVA over t-tests?

2. Which test is used to examine homoscedasticity?

3. What are the three assumptions for an ANOVA?

4. How can the F-value be computed from a given t-value?

5. Which of the statements below is true?

I. The strength of a certain effect in an ANOVA is the R^2.
II. The F-value in an ANOVA table can be calculated by dividing the mean sum of squares by the mean sum of squares of the error.

6. The following values are deduced from an ANOVA table. What is the F value?
SS between groups: 400
SS within groups: 150
df between groups: 4
df within groups: 16

7. The ANOVA-table below refers to a study about the effect of therapy on depression. Patients are assigned randomly to one of three groups. The patients in group 1 received behavioral therapy. The patients in group 2 received Cognitive Behavioral Therapy (CBT). The patients in group 3 received no therapy (control group). The dependent variable is anxiety complains after the therapy.

	SS	df	MS
Between	40		
Within			
Total	90	22	

Can it be concluded from the table above that the therapies differ significantly in effectiveness for  = .05?

8. With an ANOVA, the effect of 4 types of compost on the growth of roses is examined. For each type of compost, 10 roses are grown and weighted. What are the degrees of freedom for the conditions?

9. When are post-hoc tests used for ANOVA?

10. What does it mean when contrasts are orthogonal to each other?

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Chapter 10: ANOVA: One-way Analysis of Variance – Answers

1. What is an advantage of ANOVA over t-tests?
T-tests can be done to compare two conditions. With an ANOVA, more than two conditions can be compared.

2. Which test is used to examine homoscedasticity?
Levene's test

3. What are the three assumptions for an ANOVA?
- *Homogeneity of variances*
- *Normal distribution of the error*
- *Independent scores*

4. How can the F-value be computed from a given t-value?
The F-value can be computed as the square of the t-value.

5. Which of the statements below is true?

I. The strength of a certain effect in an ANOVA is the R^2.
II. The F-value in an ANOVA table can be calculated by dividing the mean sum of squares by the mean sum of squares of the error.

Only statement 2 is true.

6. The following values are deduced from an ANOVA table. What is the F value?
SS between groups: 400
SS within groups: 150
df between groups: 4
df within groups: 16
The F-value = 10.667

7. The ANOVA-table below refers to a study about the effect of therapy on depression. Patients are assigned randomly to one of three groups. The patients in group 1 received behavioral therapy. The patients in group 2 received Cognitive Behavioral Therapy (CBT). The patients in group 3 received no therapy (control group). The dependent variable is anxiety complains after the therapy.

	SS	df	MS
Between	40		
Within			
Total	90	22	

Can it be concluded from the table above that the therapies differ significantly in effectiveness for α = .05?
Yes, the therapies differ significantly, because $F_{obs} > F_{critical}$

8. With an ANOVA, the effect of 4 types of compost on the growth of roses is examined. For each type of compost, 10 roses are grown and weighted. What are the degrees of freedom for the conditions?
The degrees of freedom are 3, because there are 4 conditions. The degrees of freedom for the residuals are (total number of observations) – (number of conditions) = 40 – 4 = 36. The degrees of freedom for SS total is (total number of observations) – 1 = 40 -1 = 39.

9. When are post-hoc tests used for ANOVA?

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When the null hypothesis is rejected by means of the F-ratio, it implies that there is a significant difference. To examine where the difference exists (between which groups/conditions), post-hoc tests can be used. Thus, post-hoc tests are used when the null hypothesis of the ANOVA has been rejected.

10. What does it mean when contrasts are orthogonal to each other?
It means that the product of the contrast coefficients is zero.

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Chapter 11: ANOVA: Two-way Analysis of Variance – Questions

1. When is there a significant interaction effect?
   A. When the independent variables correlate significantly
   B. When the effect of an independent variable can be explained by a variable that is not included in the model
   C. When the effect of an independent variable differs significantly for the categories of the other independent variable
   D. When two independent variables significantly predict a dependent variable

2. How do you calculate the degrees of freedom for the interaction effect of A and B?

Questions 3 and 4 refer to the information below:
In 2010 a study has been conducted with regard to feelings of regret about relationships and whether these feelings differ between men and women. The sample consisted of 40 women and 29 men with a mean age of 19 years (SD = 1.18). Each participant filled out a questionnaire using the following instructions: When you look back at your relationship, is there something you regret? Something you wish you had done differently? Something you wish you had or had not done?

Bram and Timo have to do a research project for statistics. After reading the article about the regret study, they set up a similar study. Together they have made a list with potentially awkward situations that may happen during a relationship (for example: Answering the questions "Do you think I am fat?" with "Yes"). Forty students participate in this study: 20 female students and 20 male students. They are asked to determine how much they regret some described situations, in which a 0 implies no regret and a 10 implies a lot of regret. Half of the men and half of the women is asked to answer questions with regard to a romantic relationship. The other half is asked to answer questions with regard to a friendly relationship.

SPSS output of the results is given below.

Between-subject factors

		Value label	N
Gender	1	Men	20
	2	Women	20
Relationship	1	Romantic	20
	2	Friendly	20

Test of between-subject effects
Dependent variable: extent of regret

Source	Type III sum of squares	Df	Mean Square	F	Sig.
Corrected model	49.658		16.533	8.297	0.000
Intercept	1783.049		1783.049	893.781	0.000
Gender	0.780				0.536
Relationship	32.513				0.000
Gender*Relationship	16.365				0.007
	71.818				
Error	1904.525		1.995		
Total	121.477				
Corrected total					

3. The degrees of freedom are missing in the SPSS output. How many degrees of freedom are there for the interaction-effect between gender and relationship?

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4. What is the value of the test statistic for the difference in extent of regret scores between romantic and friendly relationships?

5. In a study about “the extent to which children are sexually educated by their parents”, boys and girls fill out a questionnaire about sexuality and promiscuity. If we want to compare promiscuity scores between boys and girls en between educated and non-educated youth, which analysis technique should we use?

6. Which measure of effect is used for factorial ANOVA?

7. Is it wise to use 4 factors in an ANOVA? Explain.

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Chapter 11: ANOVA: Two-way Analysis of Variance – Answers

1. When is there a significant interaction effect?
   A. When the independent variables correlate significantly
   B. When the effect of an independent variable can be explained by a variable that is not included in the model
   C. When the effect of an independent variable differs significantly for the categories of the other independent variable
   D. When two independent variables significantly predict a dependent variable

2. How do you calculate the degrees of freedom for the interaction effect of A and B?
df between treatments – df of A – df of B

3. The degrees of freedom are missing in the SPSS output. How many degrees of freedom are there for the interaction-effect between gender and relationship?
df = 1

4. What is the value of the test statistic for the difference in extent of regret scores between romantic and friendly relationships?
16.298

5. In a study about "the extent to which children are sexually educated by their parents", boys and girls fill out a questionnaire about sexuality and promiscuity. If we want to compare promiscuity scores between boys and girls en between educated and non-educated youth, which analysis technique should we use?
Two-way ANOVA.
In practice, behavior is influenced by many different factors that interact with each other. To examine these complex effects, a researcher often studies more than one independent variable. In short: researchers manipulate two or more variables to observe the effect on behavior. A design with more than one factor is called a factorial design. The ANOVA with two factors combines multiple hypotheses. Therefore, multiple hypothesis tests should be conducted. Again, the F ratio is used: differences between sample means divided by differences expected by coincidence or sampling error.

6. Which effect size/measure is used for factorial ANOVA?
The eta-squared.

7. Is it wise to use 4 factors in an ANOVA? Explain.
No, if there are more than three factors used, the results become incomprehensible and difficult to interpret. It is therefore best to use no more than three factors.

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Chapter 12: ANCOVA– Questions

1. In an experiment the effect of amphetamine on the increase of the dopamine concentration in the brains of male and female mice is examined.
   - Dopamine: concentration Dopamine
   - Amphetamine: concentration of administered amphetamine
   - Gender: man, women

Why is an ANCOVA used to analyse the data of this experiment?

2. Because of which two reasons is it useful to add covariates?

3. When are adapted group means used?

4. Which three specific assumptions are present for the ANCOVA?

5. What are the disadvantages of using covariates?

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Chapter 12: ANCOVA– Answers

1. In an experiment the effect of amphetamine on the increase of the dopamine concentration in the brains of male and female mice is examined.
   - Dopamine: concentration Dopamine
   - Amphetamine: concentration of administered amphetamine
   - Gender: man, women

Why is an ANCOVA used to analyse the data of this experiment?
An ANCOVA is used, because this experiment contains both categorical and numeric exploratory variables.

2. Because of which two reasons is it useful to add covariates?
Adding covariates makes it possible to test the effect of factors more accurately and specifically by (1) decreasing the error variance and (2) eliminating systematic bias.

3. When are adapted group means used?
When the groups differ on the covariate.

4. Which three specific assumptions are present for the ANCOVA?
   - *No error in the covariance*
   - *Linear relationship with the dependent variable*
   - *Parallelism*

5. What are the disadvantages of using covariates?
Covariates should be used moderately, because they "cost" a degree of freedom and may be difficult to interpret.

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Chapter 13: MANOVA and DA (Discriminant Analysis) – Questions

1. When is a MANOVA used?

2. When should one not use a MANOVA?
   A. When a set of dependent variables correlates strongly
   B. When you want to examine multiple categories of the independent variable
   C. When de dependent variables correlate moderately
   D. When you want to identify which dependent variables cause most of the group difference

3. A professor realizes that he has a problem, but he still wants to publish that one significant result. He corrects for the fact that he has repeated this study 20 times by using a Bonferroni correction. Take alpha = 0.05. Bonferroni advises to decrease the alpha, so that for all experiments the chance on a type I error remains below 0.05. Which value for alpha would advised by Bonferroni for the current study?

4. What are the two reasons for performing a MANOVA instead of multiple ANOVA's?

5. Which of the statements below about the MANOVA is or are correct.

   I. An advantage of a multivariate factorial design is that it shows how the independent variables interact such that they influence the dependent variable.
   II. The value of Wilk's lambda refers to the proportion of unexplained variance.

6. What is the difference between the MANOVA and the Discriminant Analysis (DA)?

7. When is the box-M test used?

8. What is the maximum number of discriminant function variates?

9. What are the two main disadvantages of DA?

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Chapter 13: MANOVA and DA (Discriminant Analysis) – Answers

1. When is a MANOVA used?
MANOVA ('Multivariate Analysis of Variance') is used to test the effects of two or more conditions on two or more dependent variables.
MANOVA is reasonably clear: we have a number of dependent interval variables (p) that we predict from one or more categorical variables divided by k groups. This is called: multivariate variance-analysis. We focus on the comparison of means, but meanwhile we look at multiple variables at the same time in a mutual association (= multivariate). When the focus is only on one dependent variable, we use the ANOVA. When the focus is on more than one dependent variable, we use the MANOVA.

2. When should one not use a MANOVA?
   A. *When a set of dependent variables correlates strongly*
   B. When you want to examine multiple categories of the independent variable
   C. When de dependent variables correlate moderately
   D. When you want to identify which dependent variables cause most of the group difference

3. A professor realizes that he has a problem, but he still wants to publish that one significant result. He corrects for the fact that he has repeated this study 20 times by using a Bonferroni correction. Take alpha = 0.05. Bonferroni advises to decrease the alpha, so that for all experiments the chance on a type I error remains below 0.05. Which value for alpha would advised by Bonferroni for the current study?
0.00250
The chance that a correct null hypothesis is not rejected (while it should), for alpha = 0.05, equals 0.95. When he repeats the experiment, the chance that the null hypothesis is not rejected at both is 0.95 x 0.95 = 0.9025 and the chance that the null hypothesis is rejected once is 0.0975. This is larger than alpha. When he repeats the experiment even more often, the chance that the null hypothesis will be rejected at least once, increases more and more. To keep this chance of rejecting H0 at least once within limits, the original value of alpha is adapted and taken smaller than 0.05. The Bonferroni method computes the exact value of alpha: when repeating the experiment 20 times, the Bonferroni provides the value (0.05/20) = 0.0025.

4. What are the two reasons for performing a MANOVA instead of multiple ANOVA's?
   - *Sometimes, the dependent variables are associated with each other.*
   - *The more tests are performed, the higher the chance on a type-I error becomes. Because of this, an ANOVA is preferred over multiple t-tests. However, the chances on a type-I error also increase when we perform multiple ANOVA's. Hence, a MANOVA is preferred when testing multiple dependent variables.*

5. Which of the statements below about the MANOVA is or are correct.

   III. An advantage of a multivariate factorial design is that it shows how the independent variables interact such that they influence the dependent variable.
   IV. The value of Wilk's lambda refers to the proportion of unexplained variance.

Both statements are true.

6. What is the difference between the MANOVA and the Discriminant Analysis (DA)?
The X (independent) and Y (dependent) are switched.

7. When is the box-M test used?
The Box-M test is used to test the assumption of equal variance-covariance matrices.

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8. What is the maximum number of discriminant function variates?
The maximum number of discriminant functions is k-1, or p. One should choose the smallest of the two.

9. What are the two main disadvantages of DA?
The main disadvantages of DA are that (1) the results are sometimes difficult to interpret and (2) the results are more descriptive than confirmative. In addition, DDA is relatively less popular than MANOVA for interpretation among researchers and journals (although this is sometimes due to wrong reasons).

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Chapter 14: Random variables – Questions

1. What is the difference between a random-effects and a fixed-effects model?

2. What causes the difference in effect sizes when comparing fixed-factor models?

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Chapter 14: Random variables – Answers

1. What is the difference between a random-effects and a fixed-effects model?
In a random-effects model, the levels of the independent variable are drawn randomly from the levels of the population for all samples. Because of this, generalizations can be made about all levels of the population. In the fixed-effects model, the levels of the independent variable are selected first. After that, the subjects are assigned randomly to the levels on the independent variable.

2. What causes the difference in effect sizes when comparing fixed-factor models?
The differences in effect sizes are caused by random sampling error.