

i Information

MAE4011 – Principles of Measurement

Spring 2025

20 March 2025 9-13 (4 hours)

No examination support material is allowed.

i Instructions

Dear student,

Some guidelines for the MAE4011 exam:

- The exam consists of a combination of multiple choice questions and open-response questions.
- It is totally fine to respond in bullet points, as long as no important information gets lost.
- For the computational tasks, it is sufficient to show how you *would* obtain the respective coefficients. You will find formulas in the provided external resource in the left corner.

Good luck!

Esther

1 Operationalization

A psychological researcher is interested in studying self-control. For measuring self-control, she is deciding between two measures: one self-report measure and one behavioral measure. As a self-report measure, the researcher considers using the Self-Control Scale (SCS), a questionnaire where participants rate their ability to control impulses and delay gratification based on statements like, "I am good at resisting temptation," using a Likert scale. As a behavioral measure, she considers using a temptation resistance task, where participants are left alone in a room with a bowl of candy and told they can have as much as they want, but the researcher records how many pieces they actually take. Fewer pieces taken would be considered an indicator of greater self-control. Name and briefly explain one advantage and one disadvantage of each self-control measure. (4 points)

Fill in your answer here

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Maximum marks: 4

2 Item Statistics

Your responses in text fields are saved automatically

The table below displays item difficulties p and item total correlations r for 10 items. Which items would you remove if you were to construct a shorter measure with 7 items only and why? (2 points)

Item	p	r
1	0.97	0.39
2	0.72	0.49
3	0.59	0.68
4	0.49	0.53
5	0.52	0.66
6	0.40	0.51
7	0.29	0.20
8	0.31	0.51
9	0.30	0.52
10	0.03	0.42

Fill in your answer here

Maximum marks: 2

3 Guttman Scale

Your responses in text fields are saved automatically

A researcher aims to develop a Guttman scale and collects responses from five individuals on five items, as shown in the table below. The researcher wants to assess the quality of the scale using the coefficient of reproducibility (CR). Calculate the coefficient of reproducibility based on the response patterns provided and explain what the CR tells you about the success of the researcher in constructing a Guttman scale. (3 points)

	Item 1	Item 2	Item 3	Item 4	Item 5	Score
Person 1	1	0	0	1	0	2
Person 2	1	1	0	0	1	3
Person 3	1	1	1	0	0	3
Person 4	1	1	0	1	0	3
Person 5	1	1	1	0	1	4

Fill in your answer here

Maximum marks: 3

4 Fairness

According to the 2014 Standards for Educational and Psychological Testing, "opportunity to learn" refers to: (1 point)

Select one alternative:

- ☐ The alignment between the content of a test and the specific learning outcomes of a curriculum.
- ☐ The extent to which an examinee has been exposed to instruction, knowledge, or experiences assumed by the test developer and/or user.
- ☐ The time and resources allocated to ensure that all students can master the content assessed by a test.
- ☐ The extent to which a test assesses a broad range of abilities that students have been taught during their education.

Maximum marks: 1

6 CTT I

Your responses in text fields are saved automatically

In classical test theory, we denote with X the observed score of a test, with T its true score and with E its error score. Derive the covariance between X and T , drawing on the axioms of classical test theory and variance and covariance algebra. (2 points)

Fill in your answer here

Maximum marks: 2

7 CTT II

We can use the observed correlation between scores on parallel tests $\frac{\sigma_{XX'}}{\sigma_X\sigma_{X'}} = \frac{\sigma_{XX'}}{\sigma_X^2} = \frac{\sigma_T^2}{\sigma_X^2}$ as an estimate of reliability. Why does the same not hold for tau-equivalent tests? (1 point)

Select one alternative:

- ☐ Because tau-equivalent tests allow for different true score variances.
- ☐ Because error variances are assumed to be uncorrelated in parallel tests but not in tau-equivalent tests.
- ☐ Because tau-equivalent tests do not assume equal total variance.
- ☐ Because $\sigma_{XX'} = \sigma_T^2$ does not hold when tests are tau-equivalent.

Maximum marks: 1

8 CTT III

Which of the following statements are always true for the classical true score model? (1 point)

Select one alternative:

- ☐ The error variances of different observed scores are the same.
- ☐ The true score has a normal distribution.
- ☐ Higher true score variance means lower reliability.
- ☐ True scores and error scores are uncorrelated.

Maximum marks: 1

9 Reliability I

Your responses in text fields are saved automatically

You have a 40-item test with an estimated reliability of .20. If you expanded it to an 80-item test by adding parallel items, what reliability would you expect? It is sufficient to write down how you would compute reliability. You do not have to provide the exact number. (1 point)

Fill in your answer here

Maximum marks: 1

10 Reliability II

Your responses in text fields are saved automatically

You have a 40-item test with an estimated reliability of .70. How many items would you need for the test to reach an expected reliability of .90? It is sufficient to write down how you would compute the required number of items. You do not have to provide the exact number. (1 point)

Fill in your answer here

Maximum marks: 1

11 Reliability III

Your responses in text fields are saved automatically

Assume we have a test X with true score variance $\sigma_T^2 = 0.60$ and error score variance $\sigma_E^2 = 0.40$.

(a) Obtain the reliability of the test X .

(b) Now, assume we have two parallel tests X_1 and X_2 , each with true score variance $\sigma_T^2 = 0.60$ and error score variance $\sigma_E^2 = 0.40$. Obtain the reliability of the sum scores across the two parallel tests

$Y = X_1 + X_2$. It is sufficient to write down how you would compute reliability. You do not have to provide the exact number. (3 points)

Fill in your answer here

Maximum marks: 3

12 Reliability IV

When is coefficient alpha equal to the classical test theory reliability coefficient? (1 point)

Select one alternative:

- ☐ When the error variances are all equal.
- ☐ When the error variance is larger than the true score variance.
- ☐ When the items have equal factor loadings.
- ☐ When the item scores all have the same mean.

Maximum marks: 1

- (1) Predictive validity evidence
- (2) Validity evidence based on the internal structure
- (3) Convergent validity evidence
- (4) Discriminant validity evidence (6 points)

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(2) Obtain the disattenuated correlation between the student self report and the teacher report of depression, accounting for measurement error in both measures. It is sufficient to write down how you would compute correlation. You do not have to provide the exact number. (6 points)

Measure	Self-report		Teacher Report	
	Depression	Anxiety	Depression	Anxiety
Self-report				
Depression	0.80			
Anxiety	.35	0.70		
Teacher report				
Depression	.25	.20	0.70	
Anxiety	.15	.35	.80	0.60

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Maximum marks: 6

15 Confirmatory Factor Analysis I

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A researcher wants to evaluate the properties of a newly developed three item measure, with items Q4, Q9, and Q14. The figure displays the parameter estimates obtained from fitting a unidimensional confirmatory factor analysis model. Use the output to obtain an estimate of McDonald's ω . It is sufficient to write down how you would compute McDonald's ω . You do not have to provide the exact number. (2 points)

	lhs	op	rhs	est	se	z	pvalue	ci.lower	ci.upper	std.lv	std.all
1	F	=~	Q4	1.000	0.000	NA	NA	1.000	1.000	1.138	0.784
2	F	=~	Q9	0.898	0.029	30.855	0	0.841	0.955	1.022	0.720
3	F	=~	Q14	1.008	0.032	31.400	0	0.945	1.071	1.147	0.770
4	Q4	~~	Q4	0.811	0.040	20.060	0	0.732	0.890	0.811	0.385
5	Q9	~~	Q9	0.969	0.038	25.246	0	0.894	1.044	0.969	0.481
6	Q14	~~	Q14	0.902	0.042	21.304	0	0.819	0.985	0.902	0.407
7	F	~~	F	1.295	0.064	20.137	0	1.169	1.421	1.000	1.000
8	Q4	~1		2.636	0.029	90.741	0	2.579	2.693	2.636	1.817
9	Q9	~1		2.233	0.028	78.600	0	2.177	2.289	2.233	1.574
10	Q14	~1		2.956	0.030	99.164	0	2.897	3.014	2.956	1.985
11	F	~1		0.000	0.000	NA	NA	0.000	0.000	0.000	0.000

Fill in your answer here

Maximum marks: 2

16 Confirmatory Factor Analysis II

Which of the following assumptions and constraints are made in an essentially tau-equivalent confirmatory factor analysis model (select all that apply)

Select one or more alternatives:

- ☐ All item intercepts are constrained to be equal
- ☐ The model is assumed to be unidimensional
- ☐ All item error variances are constrained to be equal
- ☐ All item loadings are constrained to be equal

Maximum marks: 1