“SO, YOU WANT TO CREATE A SURVEY”

PART 1A: TESTING VALIDITY AND INTERNAL CONSISTENCY

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AGENDA

- Some survey design principles
- Identifying patterns with EFA
  - Let's practice what we've learned
  - Checking Internal Reliability of our factors
- Confirming models with CFA

WHAT KIND OF SURVEYS ARE WE LOOKING AT?

- The types of analysis we will discuss today work best when creating surveys that measure the affective domain
- Constructs are generally latent, meaning that they cannot be observed.
  - Latent constructs must be inferred by observing behaviors that are indicators of the underlying constructs.
- In the social sciences, we study latent constructs such as:
  - creativity
  - intelligence
  - motivation
  - academic self-concept
  - anxiety

CRAFTING SURVEY QUESTIONS

- **Use clear and neutral wording**
  - Neutral wording prevents bias and ensures responses reflect true opinions.
  - Be specific and concrete with your questions
  - Instead of **"Don't you think this policy is unfair?"**, you could ask, **"To what extent do you agree with this policy?"**
- **Focus on one idea per question, i.e., avoid "double-barreled" questions**
  - Instead of **"How satisfied are you with the product's quality and price?"**, split the question into two:
    - "How satisfied are you with the product's quality?"
    - "How satisfied are you with the product's price?"

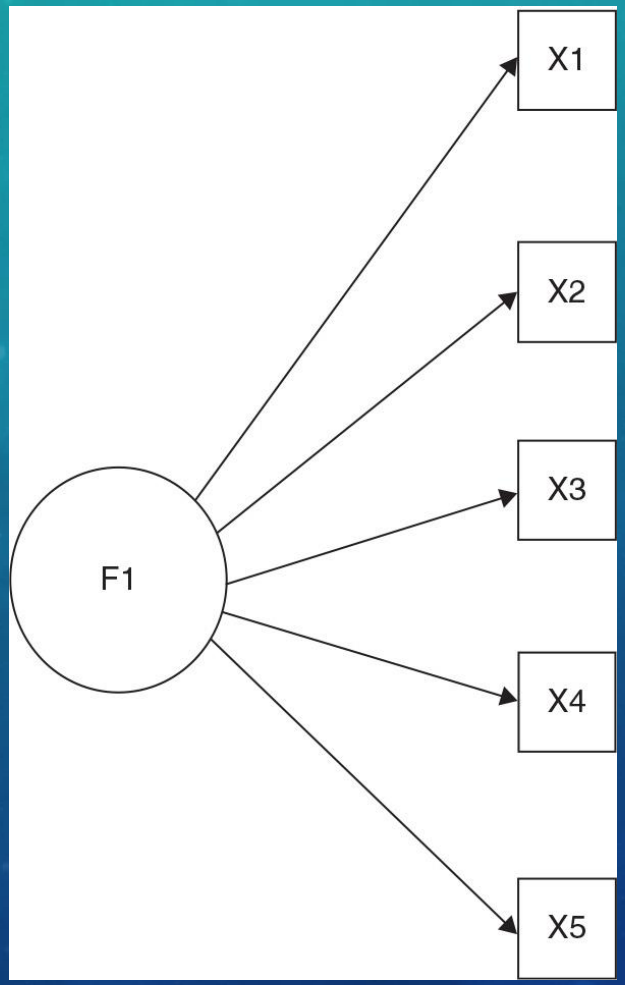
CRAFTING SURVEY QUESTIONS

- **Be consistent in how your items are worded**
  - Mixing positively and negatively worded items can confuse participants:
    - **Positive wording:** “I feel confident in my ability to analyze data.”
    - **Negative wording:** “I do not feel confident in my ability to analyze data.”
  - If it cannot be avoided, make sure to reverse-code the results of these questions before analysis
- **Keep question-wording simple and direct**
  - Clear language ensures respondents understand the question without misinterpretation.
  - Avoid jargon, use correct grammar/spelling, write questions at the appropriate knowledge level
  - Instead of "How would you rate the intuitiveness of this system based on HCI principles?", use "How easy is this system to use?"

CRAFTING SURVEY QUESTIONS

- **Find "Face validity" by pre-testing your survey**
  - Search for readability and understandability with members of your target population
  - If an item or scale is not aligning with your intended meaning, rewrite or remove it as needed
- **Find "Content validity" by sharing your survey with experts:**
  - Look for persons with expertise in the theoretical framework behind your survey
  - Can help you evaluate if the questions you developed align with the theory and best practices

WHAT IS A FACTOR?



WHAT IS IT GOOD FOR? EXPLORATORY FACTOR ANALYSIS (A.K.A. EFA)

- To understand the structure of a set of variables
  - (e.g., Spearman and Thurstone used factor analysis to try to understand the structure of the latent variable ‘intelligence’);
- To construct a survey to measure an underlying variable
  - (e.g., you might design a questionnaire to measure burnout)
- In survey development, EFA Provides empirical evidence of the relationship between theoretical dimensions of the latent construct and the survey items that were developed
  - Reduce a large number of observed variables into a smaller set, i.e., our factor solution

EFA: GENERAL STEPS

1. Evaluate your sample adequacy
   - KMO-tests (KMO>0.6) + Bartlett's test (p-value<0.05)
2. Determine the number of factors to extract
   - Scree plot + parallel analysis + Kaiser's criterion
3. Determine your extraction and rotation techniques
   - Principal axis factoring (PAF) is one of the most commonly used
   - Determine rotation technique
     - Oblique: Direct oblimin, or **Promax**
     - Orthogonal: Equimax, Quartimax, or **Varimax**
4. Evaluate factor solution
   - Eliminate items that do not load highly on any factor or crossload
   - Interpret factors

OUR DATA: THE SPSS ANXIETY QUESTIONNAIRE

We want to know how many factors are present in the “SPSS Anxiety” construct

- Total 23 questions with 2571 survey answers
  - Measured on a 5-point Likert scale anchored from “Strongly Agree” (1) to “Strongly Disagree” (5)
  - Some survey answers have missing values; we will not cover that today

- Our dataset is from **“Discovering Statistics Using IBM SPSS Statistics”** by Andy Field (2024), 6th edition
  - Check out www.instagram.com/DISCOVERING_CATISTICS/

OUR DATA: THE SPSS ANXIETY QUESTIONNAIRE

- I have little experience of computers
- SPSS always crashes when I try to use it
- I worry that I will cause irreparable damage because of my incompetence with computers
- All computers hate me
- Computers are useful only for playing games
- Computers are out to get me
- I don't understand statistics
- Computers have minds of their own and deliberately go wrong whenever I use them
- My friends are better at statistics than me
- If I'm good at statistics my friends will think I'm a nerd
- Everybody looks at me when I use SPSS
- My friends are better at SPSS than I am
- My friends will think I'm silly for not being able to cope with SPSS
- I have never been good at mathematics
- I did badly at mathematics at school
- I slip into a coma whenever I see an equation
- I wake up under my duvet thinking that I am trapped under a normal distribution
- I dream that Pearson is attacking me with correlation coefficients
- I can't sleep for thoughts of eigenvectors
- I weep openly at the mention of central tendency
- Standard deviations excite me
- Statistics makes me cry
- People try to tell you that SPSS makes statistics easier to understand but it doesn't

SAMPLE ADEQUACY: TWO TESTS

- **Kaiser-Meyer-Olkin** measure of sampling adequacy **(KMO)**
  - KMO values range from 0 – 1
  - Higher KMO values indicate that if an EFA were conducted, extracted factors would account for a large amount of the variance
- In general (from Kaiser and Rice (1974)):
  - Marvelous: values in the 0.90s
  - Meritorious: values in the 0.80s
  - Middling: values in the 0.70s
  - Mediocre: values in the 0.60s
  - Miserable: values in the 0.50s
  - Merde (unacceptable): values below 0.50

1. SAMPLE ADEQUACY: TWO TESTS

Bartlett's test for sphericity

- **H0:** The correlation matrix is an identity matrix
- **H1:** The correlation matrix is not an identity matrix

- ***A low p-value (<0.05)** indicates that the data are suitable to perform an EFA

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6
Item 1	1.00					
Item 2	0.00	1.00				
Item 3	0.00	0.00	1.00			
Item 4	0.00	0.00	0.00	1.00		
Item 5	0.00	0.00	0.00	0.00	1.00	
Item 6	0.00	0.00	0.00	0.00	0.00	1.00

Figure 2. In an identity matrix the items are only related to themselves, this would not allow us to find factors in our survey data

1. SAMPLE ADEQUACY: RUNNING IN SPSS

1. Go to “Analyze” → “Dimension Reduction” → “Factor”
2. Add your survey items to the “Variables” box
3. Click on “Descriptives”
4. Check the box for “KMO and Bartlett’s test of sphericity”
5. Click “Continue”
6. Click “OK”

- Check your output:
  - We want KMO >0.6 (or 0.8, even better)
  - We want Bartlett’s test p-value <0.05

1. SAMPLE ADEQUACY: RUNNING IN SPSS

Check your "**KMO and Bartlett's Test**" output table:

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.930
Bartlett's Test of Sphericity	Approx. Chi-Square	19334.492
	df	253
	Sig.	<.001

- Bartlett's Test p-value is <0.001
- This shows our sample is adequate for EFA ( )

2. DETERMINING THE NUMBER OF FACTORS TO EXTRACT: THREE APPROACHES

- **Kaiser's criterion: Eigenvalues > 1**
  - Represent the number of suggested factors that should be extracted
- **Scree plot**
  - A graphical approach, we will discuss how to use it in our demonstration
- **Parallel Analysis**
  - The Eigenvalues from your real dataset are compared against eigenvalues from a randomly generated dataset that has the same characteristics as your original data
  - We need a separate "syntax" to run this in SPSS

- What happens when they don't agree?

2. DETERMINING THE NUMBER OF FACTORS TO EXTRACT: THREE APPROACHES

Your first “go” will help you determine the number of factors to extract. For **Kaiser’s criterion** and **Scree plot**:

1. Under “Go to “Analyze”, “Dimension Reduction”, “Factor”
2. Add your survey questions to the “Variables” box
3. Click on “Extraction”
   - Click the “Methods” dropdown menu, and choose “Principal Axis Factoring”
   - Under the “Display box, Select “Unrotated Factor Solution” and “Scree plot”

For Parallel Analysis:

1. Open a data file (.sav) that contains only your survey responses
2. Open the Macro Syntax: Go to File > Open > Syntax, browse to where you saved "Parallel_Analysis_Syntax.sps”
3. Use the “Run all” command to execute the macro
   - Right-click and select “Run all”, or go to the “Run” menu and select “Run all.”

2. DETERMINING THE NUMBER OF FACTORS TO EXTRACT: EVALUATING KAISER'S CRITERION

In our output, we look at the "**Total Variance Explained**" table:

- Verify the eigenvalue in the "Total" column
  - Kaiser's criterion: Eigenvalues > 1
- The "Factor" column tells you how many factors to extract

➢ Kaiser's criterion suggests a four-factor solution

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	7.290	31.696	31.696	6.744	29.323	29.323	5.919
2	1.739	7.560	39.256	1.128	4.902	34.225	5.359
3	1.317	5.725	44.981	.814	3.539	37.764	4.127
4	1.227	5.336	50.317	.624	2.713	40.477	2.423
5	.988	4.295	54.612				
6	.895	3.893	58.504				
7	.806	3.502	62.007				
8	.783	3.404	65.410				
9	.751	3.265	68.676				
10	.717	3.117	71.793				
11	.684	2.972	74.765				
12	.670	2.911	77.676				
13	.612	2.661	80.337				
14	.578	2.512	82.849				
15	.549	2.388	85.236				
16	.523	2.275	87.511				
17	.508	2.210	89.721				
18	.456	1.982	91.704				
19	.424	1.843	93.546				
20	.408	1.773	95.319				
21	.379	1.650	96.969				
22	.364	1.583	98.552				
23	.333	1.448	100.000				

Extraction Method: Principal Axis Factoring.

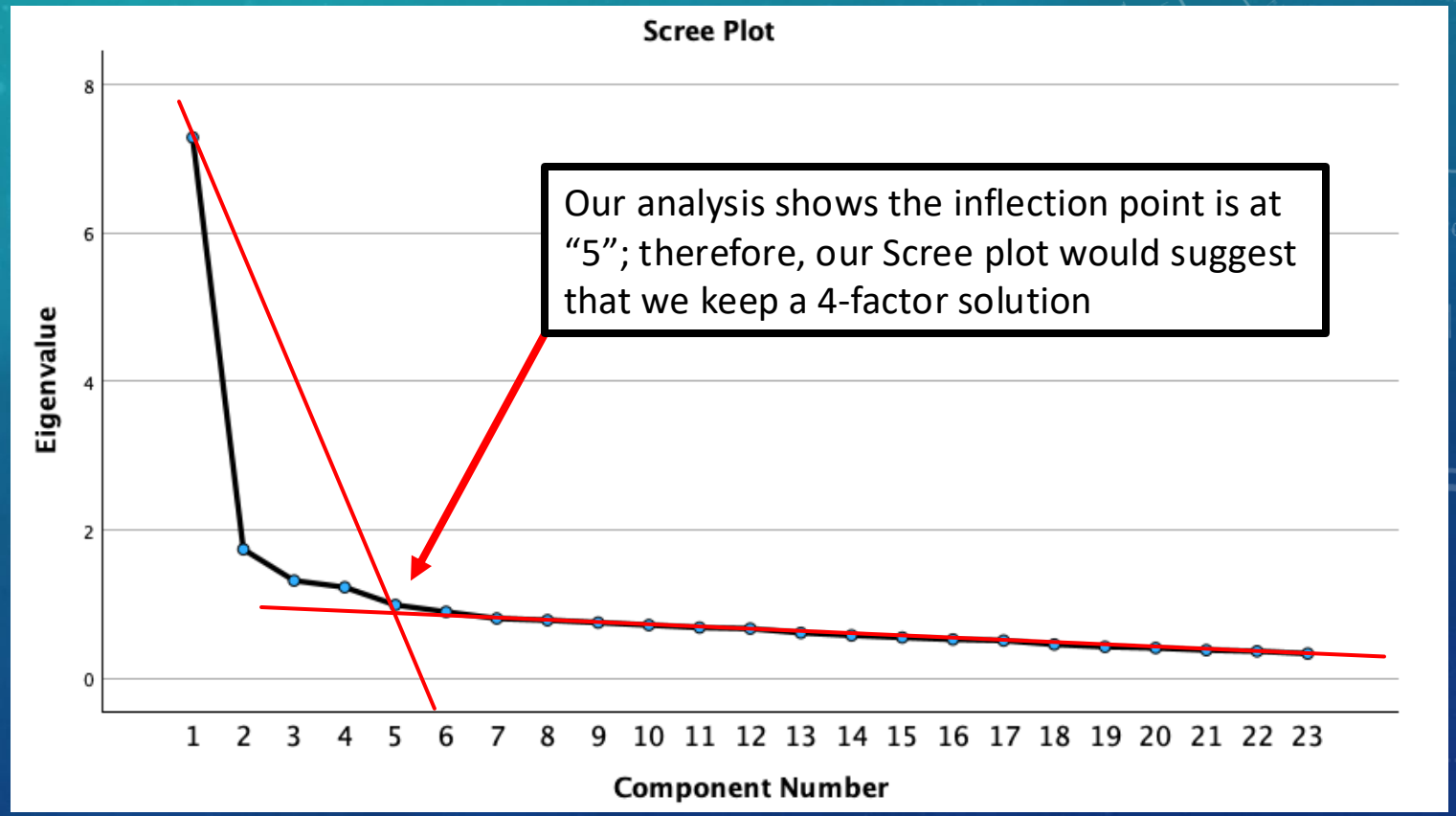
2. DETERMINING THE NUMBER OF FACTORS TO EXTRACT: EVALUATING THE SCREE PLOT

We evaluate the scree plot by finding an “inflection point”, a point where the slope of the line changes dramatically.

We can find this point by ”drawing” two straight lines:

- one “summarizes” the horizontal part of the plot
- one “summarizes” the vertical part of the plot
- The inflection point is the data point at which these two lines meet.

We keep the number of factors to the left of the inflection point.



2. DETERMINING THE NUMBER OF FACTORS TO EXTRACT: EVALUATING PARALLEL ANALYSIS

In our output, we look at the "**Parallel Analysis**" table:

- Compare the eigenvalue in the "Raw Data" column to the value in the "Prcntyle" column
- The number of factors to extract is the highest "row" number for which the "Raw Data" value is still higher than the "Prcntyle" value

- From our output, at four factors , our "Raw Data" eigenvalue is still higher than the one for the randomly generated dataset; after this, the "Prcntyle" values are higher than our "Raw Data" values. Therefore, Parallel Analysis suggests a four-factor solution.
- All three methods agree! (this is not always the case)

PARALLEL ANALYSIS:

Principal Components & Random Normal Data Generation

Specifications for this Run:
Ncases 2571
Nvars 23
Ndatsets 500
Percent 95

Raw Data Eigenvalues, & Mean & Percentile Random Data Eigenvalues

Root	Raw Data	Means	Prcntyle
1.000000	7.290047	1.170875	1.195723
2.000000	1.738829	1.145300	1.165026
3.000000	1.316752	1.124486	1.140756
4.000000	1.227198	1.107375	1.121178
5.000000	.987878	1.092299	1.106724
6.000000	.895330	1.076771	1.089357
7.000000	.805560	1.062254	1.073951
8.000000	.782820	1.049178	1.060982
9.000000	.750971	1.035835	1.046885
10.000000	.716958	1.022699	1.033762
11.000000	.683588	1.010107	1.020913
12.000000	.669502	.997406	1.007964
13.000000	.611998	.984796	.995995
14.000000	.577738	.972547	.983433
15.000000	.549188	.960618	.970741
16.000000	.523150	.947782	.959005
17.000000	.508396	.934551	.945332
18.000000	.455940	.921530	.933306
19.000000	.423804	.908277	.920111
20.000000	.407791	.894391	.907871
21.000000	.379480	.879118	.892540
22.000000	.364022	.861414	.876297
23.000000	.333062	.840389	.859739

------ END MATRIX -----

3. EXTRACT AND ROTATE YOUR FACTORS

Now that we determined how many factors we should extract, we go and try out our solution:

1. Under “Go to “Analyze” > “Dimension Reduction” > “Factor”
2. Add your survey questions to the “Variables” box
3. Click on “Extraction”
   - Click the “Methods” dropdown menu, and choose “Principal Axis Factoring”
   - In the “Extract” box click on “Fixed number of factors” and enter the number of factors determined in the previous step
   - Click “Continue”
4. Click on “Rotation”.
   - Select the desired rotation (“Promax” with kappa = 4).
   - Click “Continue”.
5. Click “OK”

4. HOW TO EVALUATE YOUR SOLUTION

We look at the **Pattern Matrix:**

- **Each row represents a question, and each column represents a factor**
  - The number in each cell represents how that question “loads” or “relates” to each factor
- **What is a “high” loading of an item on a factor?**
  - Acceptable range = magnitude ≥ 0.32
  - We typically remove items that have a factor loading < 0.32 on any factor
- **What is a cross-loading item?**
  - An item that loads with magnitude ≥ 0.32 on *more than one factor*
  - We typically remove cross-loading items from the item pool

4. HOW TO EVALUATE YOUR SOLUTION

Evaluate your "Pattern Matrix" table, remember:

- Acceptable range = magnitude ≥ 0.32
- Cross loading: An item that loads with magnitude ≥ 0.32 on *more than one factor*

- We can remove the "Computers are out to get me" item and re-run our EFA (it is an iterative process)
- Notice how the "Standard deviations excite me" item is worded positively, as opposed to the other negatively worded questions. We should reverse-code it before continuing the process.

Pattern Matrix[a]

	Factor			
	1	2	3	4
I wake up under my duvet thinking that I am trapped under a normal distribution	.691			
I can't sleep for thoughts of eigenvectors	.595			
I dream that Pearson is attacking me with correlation coefficients	.585			
I weep openly at the mention of central tendency	.578			
Statistics makes me cry	.576			
People try to tell you that SPSS makes statistics easier to understand but it doesn't	.527			
Standard deviations excite me	-.526			
I don't understand statistics	.470			
I have little experience of computers		.952		
SPSS always crashes when I try to use it		.610		
I worry that I will cause irreparable damage because of my incompetence with computers		.558		
All computers hate me		.534		
Computers have minds of their own and deliberately go wrong whenever I use them	.306	.427		
Computers are useful only for playing games		.402		
Computers are out to get me		.302		
I have never been good at mathematics			.842	
I did badly at mathematics at school			.730	
I slip into a coma whenever I see an equation			.647	
My friends are better at statistics than me				.570
My friends are better at SPSS than I am				.488
My friends will think I'm silly for not being able to cope with SPSS				.452
If I'm good at statistics my friends will think I'm a nerd				.369
Everybody looks at me when I use SPSS				.324

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

LET'S NAME OUR FACTORS

	Factor			
	1	2	3	4
I wake up under my duvet thinking that I am trapped under a normal distribution	.686			
I dream that Pearson is attacking me with correlation coefficients	.608			
I weep openly at the mention of central tendency	.604			
Statistics makes me cry	.588			
I can't sleep for thoughts of eigenvectors	.577			
People try to tell you that SPSS makes statistics easier to understand but it doesn't	.538			
Standard deviations excite me	.517			
I don't understand statistics	.489			

I have little experience of computers		.912		
SPSS always crashes when I try to use it		.581		
I worry that I will cause irreparable damage because of my incompetence with computers		.536		
All computers hate me		.507		
Computers are useful only for playing games		.375		
I have never been good at mathematics			.845	
I did badly at mathematics at school			.724	
I slip into a coma whenever I see an equation			.639	
My friends are better at statistics than me				.561
My friends are better at SPSS than I am				.495
My friends will think I'm silly for not being able to cope with SPSS				.456
If I'm good at statistics my friends will think I'm a nerd				.373
Everybody looks at me when I use SPSS				.333

LET'S NAME OUR FACTORS

- Look at the group of items associated with each factor (those that load ≥ 0.32 on the factor), and see if they “make sense” together (theoretically and/or practically)
- If factors are not meaningful, you may need to rewrite items and start again (with a new data collection…)

LET'S NAME OUR FACTORS

Factors of the SPSS Anxiety Questionaire

- Factor 1: Stats Anxiety
- Factor 2: Computer-use anxiety (... I blame Windows)
- Factor 3: Fear of Math
- Factor 4: Fear of negative peer evaluation

I HAVE MY FACTORS, WHAT NOW?

We measure **Internal consistency** using Cronbach's alpha

- We calculate internal consistency for each factor separately
- Each item set represents the "final" measurement instrument after conducting EFA
- Accepted "Alpha values" are 0.7 or higher (check the literature in your discipline)

CRONBACH'S ALPHA SPSS PROCEDURE

- Go to "Analyze," then "Scale"
- Choose "Reliability Analysis"
  - Enter the items for one of your factors in the "Items" box (you will repeat for each factor)
  - Select "Alpha" under "Model"
  - Type in "Scale Label"
- Click on "Statistics",
  - In "Descriptives for" select: 'Item' and 'Scale if item deleted';
  - In "Inter-item" select: 'Correlations'
  - In "Summaries" select: 'Means' and 'Correlations'
  - Click "Continue"
- Click "OK"

CRONBACH'S ALPHA: EXAMINING YOUR SPSS OUTPUT

- Check your "**Inter-Item Correlations Matrix**":
  - The values should be within the 0.3-0.80 range, with no negative values
  - If your alpha is below the accepted range, consider removing items that are outside the range
- In your "**Summary Item Statistics**" table:
  - Check the 'Variance' of your 'Inter-Item Correlations' row; the variance should be **< 0.01**
- In your "**Item-Total Statistics**" table:
  - Verify the column labeled "alpha if item deleted", and consider removals that lead to a higher alpha
- If you made any changes, re-run the test and examine alpha (fingers crossed alpha ≥ 0.7)

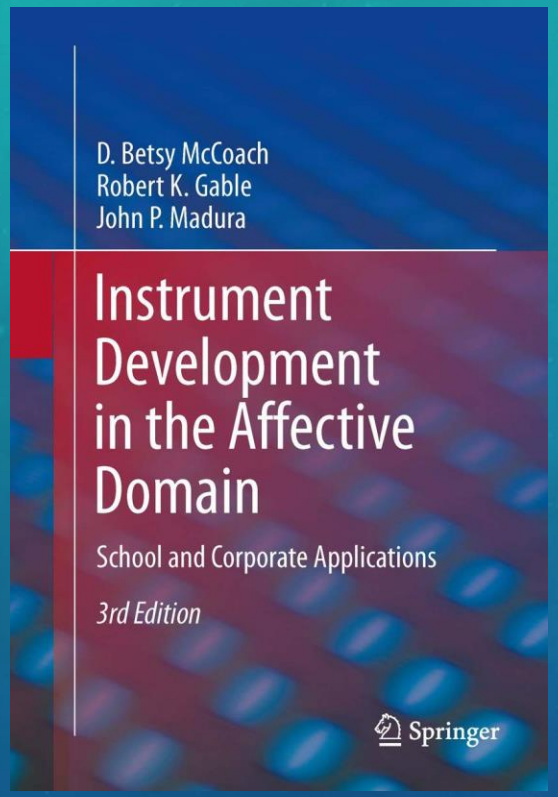
CRONBACH'S ALPHA: EXAMINING YOUR SPSS OUTPUT

- "I did all of that and my alpha is still not acceptable" 😭
- We still have a few options:
  - Consider going back to your EFA, removing additional items
  - Check for items that were reverse-coded
  - Worst-case scenario: we rewrite items and start again

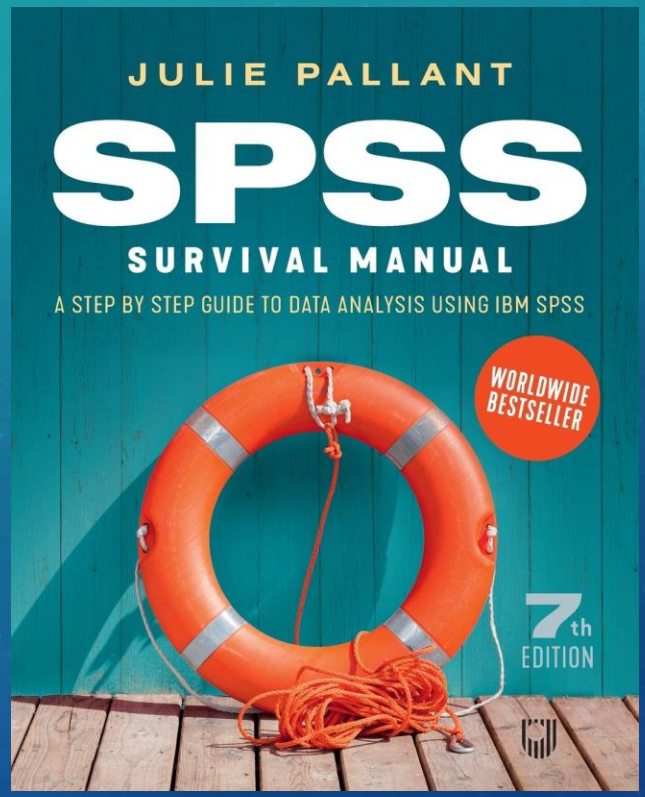
GOING FURTHER: CONFIRMATORY FACTOR ANALYSIS

- The factor model we got from EFA is the input for CFA (you now know how to do that, yay!)
- We need a new dataset, meaning more data collection
- If you are using a tested survey with a new population, do CFA instead of EFA
- SPSS is not equipped to run CFA; we have to use other software:
  - SPSS AMOS
  - LISREL
  - EQS
  - R, using the Lavaan package (this one is FREE 😎)
- We will do a demonstration on February 19, 2025 (register at lib.asu.edu/data/open-lab)

HELPFUL BOOKS AVAILABLE THROUGH YOUR ASU LIBRARY ACCOUNT



Easy to read and widely used; guides you through the different processes of survey development.



Easy to read; covers how to run many statistical tests and methods in SPSS, including EFA