

Chapter 15: Answers

Task 1

The University of Sussex is constantly seeking to employ the best people possible as lecturers (no, really, it is). Anyway, they wanted to revise a questionnaire based on Bland's theory of research methods lecturers. This theory predicts that good research methods lecturers should have four characteristics: (1) a profound love of statistics; (2) an enthusiasm for experimental design; (3) a love of teaching; and (4) a complete absence of normal interpersonal skills. These characteristics should be related (i.e. correlated). The 'Teaching Of Statistics for Scientific Experiments' (TOSSE) already existed, but the university revised this questionnaire and it became the 'Teaching Of Statistics for Scientific Experiments — Revised' (TOSSE—R). The gave this questionnaire to 239 research methods lecturers around the world to see if it supported Bland's theory. The questionnaire is below and the data are in **TOSSE-R.sav**. Conduct a factor analysis (with appropriate rotation) to see the factor structure of the data.

SD = Strongly Disagree, D = Disagree, N = Neither, A = Agree, SA = Strongly Agree						
		SD	D	N	A	SA
1	I once woke up in the middle of a vegetable patch hugging a turnip that I'd mistakenly dug up thinking it was Roy's largest root	<input type="radio"/>				
2	If I had a big gun I'd shoot all the students I have to teach	<input type="radio"/>				
3	I memorize probability values for the F-distribution	<input type="radio"/>				
4	I worship at the shrine of Pearson	<input type="radio"/>				
5	I still live with my mother and have little personal hygiene	<input type="radio"/>				
6	Teaching others makes me want to swallow a large bottle of bleach because the pain of my burning oesophagus would be light relief in comparison	<input type="radio"/>				
7	Helping others to understand Sums of Squares is a great feeling	<input type="radio"/>				
8	I like control conditions	<input type="radio"/>				
9	I calculate 3 ANOVAs in my head before getting out of bed every morning	<input type="radio"/>				
10	I could spend all day explaining statistics to people	<input type="radio"/>				
11	I like it when people tell me I've helped them to understand factor rotation	<input type="radio"/>				
12	People fall asleep as soon as I open my mouth to speak	<input type="radio"/>				

13	Designing experiments is fun	<input type="radio"/>				
14	I'd rather think about appropriate dependent variables than go to the pub	<input type="radio"/>				
15	I soil my pants with excitement at the mere mention of Factor Analysis	<input type="radio"/>				
16	Thinking about whether to use repeated or independent measures thrills me	<input type="radio"/>				
17	I enjoy sitting in the park contemplating whether to use participant observation in my next experiment	<input type="radio"/>				
18	Standing in front of 300 people in no way makes me lose control of my bowels	<input type="radio"/>				
19	I like to help students	<input type="radio"/>				
20	Passing on knowledge is the greatest gift you can bestow an individual	<input type="radio"/>				
21	Thinking about Bonferroni corrections gives me a tingly feeling in my groin	<input type="radio"/>				
22	I quiver with excitement when thinking about designing my next experiment	<input type="radio"/>				
23	I often spend my spare time talking to the pigeons ... and even they die of boredom	<input type="radio"/>				
24	I tried to build myself a time machine so that I could go back to the 1930s and follow Fisher around on my hands and knees licking the floor on which he'd just trodden	<input type="radio"/>				
25	I love teaching	<input type="radio"/>				
26	I spend lots of time helping students	<input type="radio"/>				
27	I love teaching because students have to pretend to like me or they'll get bad marks	<input type="radio"/>				
28	My cat is my only friend	<input type="radio"/>				

SPSS Output

Correlation Matrix^a

a. Determinant = 1.498E-06

Multicollinearity: The determinant of the correlation matrix was 0.00000149, which is smaller than 0.00001 and, therefore, indicates that multicollinearity could be a problem in these data (although, strictly speaking, because we're using principal components analysis we don't need to worry).

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.894
Bartlett's Test of Sphericity	Approx. Chi-Square	3015.282
	df	378
	Sig.	.000

Communalities

	Initial	Extraction
I once woke up in the middle of a vegetable patch hugging a turnip that I'd mistakenly dug up thinking it was Roy's largest root	1.000	.631
If I had a big gun I'd shoot all the students I have to teach	1.000	.641
I memorize probability values for the F-distribution	1.000	.558
I worship at the shrine of Pearson	1.000	.568
I still live with my mother and have little personal hygiene	1.000	.561
Teaching others makes me want to swallow a large bottle of bleach because the pain of my burning oesophagus would be light relief in comparison	1.000	.638
Helping others to understand Sums of Squares is a great feeling	1.000	.484
I like control conditions	1.000	.682
I calculate 3 ANOVAs in my head before getting out of bed every morning	1.000	.632
I could spend all day explaining statistics to people	1.000	.409
I like it when people tell me I've helped them to understand factor rotation	1.000	.542
People fall asleep as soon as I open my mouth to speak	1.000	.263
Designing experiments is fun	1.000	.521
I'd rather think about appropriate dependent variables than go to the pub	1.000	.696
I soil my pants with excitement at the mere mention of Factor Analysis	1.000	.498
Thinking about whether to use repeated or independent measures thrills me	1.000	.676
I enjoy sitting in the park contemplating whether to use participant observation in my next experiment	1.000	.709
Standing in front of 300 people in no way makes me lose control of my bowels	1.000	.519
I like to help students	1.000	.540
Passing on knowledge is the greatest gift you can bestow an individual	1.000	.480
Thinking about Bonferroni corrections gives me a tingly feeling in my groin	1.000	.557
I quiver with excitement when thinking about designing my next experiment	1.000	.763
I often spend my spare time talking to the pigeons ... and even they die of boredom	1.000	.605
I tried to build myself a time machine so that I could go back to the 1930s and follow Fisher around on my hands and knees licking the floor on which he'd just trodden	1.000	.653
I love teaching	1.000	.541
I spend lots of time helping students	1.000	.593
I love teaching because students have to pretend to like me or they'll get bad marks	1.000	.625
My cat is my only friend	1.000	.561

Extraction Method: Principal Component Analysis.

Sample Size: McCallum et al (1999) have demonstrated that when communalities after extraction are above .5, a sample size between 100-200 can be adequate and even when communalities are below .5 a sample size of 500 should be sufficient. We have a sample size of 239 with some communalities below .5, and so the sample size may not be adequate. However, the KMO measure of sampling adequacy is .894, which is above Kaiser's (1974) recommendation of .5. This value is also 'meritorious' (and almost 'marvelous') according to Hutcheson & Sofroniou (1999). As such, the evidence suggests that the sample size is adequate to yield distinct and reliable factors.

Bartlett's test: This tests whether the correlations between questions are sufficiently large for factor analysis to be appropriate (it actually tests whether the correlation matrix is sufficiently different from an identity matrix). In this case it is significant ($\chi^2(378) = 2989.77, p < .001$) indicating that the correlations within the R-matrix are sufficiently different from zero to warrant factor analysis.

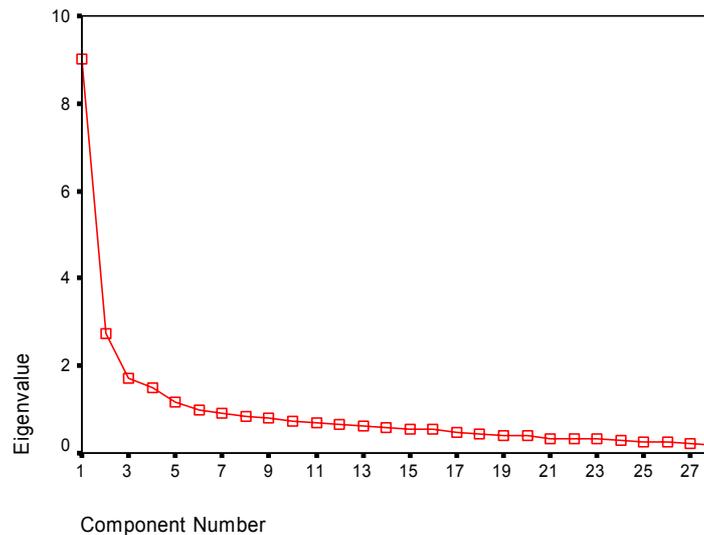
Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	9.028	32.243	32.243	9.028	32.243	32.243	6.923
2	2.750	9.823	42.066	2.750	9.823	42.066	3.752
3	1.709	6.102	48.169	1.709	6.102	48.169	3.693
4	1.504	5.370	53.539	1.504	5.370	53.539	5.238
5	1.155	4.127	57.665	1.155	4.127	57.665	3.159
6	.975	3.482	61.147				
7	.921	3.289	64.436				
8	.828	2.957	67.394				
9	.789	2.819	70.212				
10	.734	2.620	72.832				
11	.708	2.529	75.362				
12	.658	2.350	77.711				
13	.627	2.240	79.951				
14	.584	2.085	82.036				
15	.549	1.960	83.996				
16	.539	1.925	85.921				
17	.492	1.757	87.678				
18	.453	1.619	89.297				
19	.412	1.471	90.768				
20	.399	1.426	92.195				
21	.341	1.218	93.412				
22	.336	1.200	94.612				
23	.314	1.122	95.734				
24	.289	1.033	96.767				
25	.271	.966	97.733				
26	.255	.911	98.644				
27	.212	.759	99.403				
28	.167	.597	100.000				

Extraction Method: Principal Component Analysis.

- a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Scree Plot



Extraction: SPSS has extracted 5 factors based on Kaiser’s criterion of retaining factors with eigenvalues greater than 1. Is this warranted? Kaiser’s criterion is accurate when there are less than 30 variables and the communalities after extraction are greater than .7, or when the sample size exceeds 250 and the average communality is greater than .6. For these data the sample size is 239, there are 28 variables, and the mean communality is .577 so extracting 5 factors is not really warranted. The scree plot shows clear inflexions at 3 and 5 factors and so using the scree plot you could justify extracting 3 or 5 factors.

Pattern Matrix^a

	Component				
	1	2	3	4	5
Thinking about whether to use repeated or independent measures thrills me	.829				
I'd rather think about appropriate dependent variables than go to the pub	.813				
I quiver with excitement when thinking about designing my next experiment	.765				
I enjoy sitting in the park contemplating whether to use participant observation in my next experiment	.733				
Designing experiments is fun	.575				
I like control conditions	.556				
I could spend all day explaining statistics to people	.458				
I calculate 3 ANOVAs in my head before getting out of bed every morning					
I like to help students		.735			
Passing on knowledge is the greatest gift you can bestow an individual		.651			
I love teaching		.633			
I love teaching because students have to pretend to like me or they'll get bad marks		.556			
Helping others to understand Sums of Squares is a great feeling		.470			
I spend lots of time helping students		.461			
I like it when people tell me I've helped them to understand factor rotation					
I often spend my spare time talking to the pigeons ... and even they die of boredom			.713		
My cat is my only friend			.702		
I still live with my mother and have little personal hygiene			.692		
People fall asleep as soon as I open my mouth to speak			.493		
I tried to build myself a time machine so that I could go back to the 1930s and follow Fisher around on my hands and knees licking the floor on which he'd just trodden				.752	
I memorize probability values for the F-distribution				.662	
I worship at the shrine of Pearson				.589	
I soil my pants with excitement at the mere mention of Factor Analysis				.481	
Thinking about Bonferroni corrections gives me a tingly feeling in my groin	.433			.479	
I once woke up in the middle of a vegetable patch hugging a turnip that I'd mistakenly dug up thinking it was Roy's largest root				.445	
Teaching others makes me want to swallow a large bottle of bleach because the pain of my burning oesophagus would be light relief in comparison					.818
If I had a big gun I'd shoot all the students I have to teach					.784
Standing in front of 300 people in no way makes me lose control of my bowels					.549

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 15 iterations.

Rotation: You should chose an oblique rotation because the question says that the constructs we're measuring are related.

Looking at the pattern matrix (and using loadings greater than .4 as recommended by Stevens) we see the following pattern:

Factor 1:

- Q 16. Thinking about whether to use repeated or independent measures thrills me
- Q 14. I'd rather think about appropriate dependent variables than go to the pub
- Q 22. I quiver with excitement when thinking about designing my next experiment

- Q 17. I enjoy sitting in the park contemplating whether to use participant observation in my next experiment
- Q 13. Designing experiments is fun
- Q 8. I like control conditions
- Q 10. I could spend all day explaining statistics to people

Factor 2:

- Q 9. I calculate 3 ANOVAs in my head before getting out of bed every morning
- Q 19. I like to help students
- Q 20. Passing on knowledge is the greatest gift you can bestow an individual
- Q 25. I love teaching
- Q 27. I love teaching because students have to pretend to like me or they'll get bad marks
- Q 7. Helping others to understand Sums of Squares is a great feeling
- Q 26. I spend lots of time helping students

Factor 3:

- Q 23. I often spend my spare time talking to the pigeons ... and even they die of boredom
- Q 28. My cat is my only friend
- Q 5. I still live with my mother and have little personal hygiene
- Q 12. People fall asleep as soon as I open my mouth to speak

Factor 4:

- Q 24. I tried to build myself a time machine so that I could go back to the 1930s and follow Fisher around on my hands and knees licking the floor on which he'd just trodden
- Q 3. I memorize probability values for the F-distribution
- Q 4. I worship at the shrine of Pearson
- Q 15. I soil my pants with excitement at the mere mention of Factor Analysis
- Q 21. Thinking about Bonferroni corrections gives me a tingly feeling in my groin
- Q 1. I once woke up in the middle of a vegetable patch hugging a turnip that I'd mistakenly dug up thinking it was Roy's largest root

Factor 5:

- Q 6. Teaching others makes me want to swallow a large bottle of bleach because the pain of my burning oesophagus would be light relief in comparison
- Q 2. If I had a big gun I'd shoot all the students I have to teach
- Q 18. Standing in front of 300 people in no way makes me lose control of my bowels

No Factor:

- Q 11. I like it when people tell me I've helped them to understand factor rotation

Factor 1 seems to relate to research methods, factor 2 to teaching, factor 3 to general social skills, factor 4 to statistics and factor 5 to, well, err, teaching again. All in all this isn't

particularly satisfying and doesn't really support the four factor model. We saw earlier that the extraction of 5 factors probably wasn't justified. In fact the scree plot seems to indicate 3. Let's re-run the analysis but asking SPSS for three factors. Let's see how this changes the pattern matrix:

Pattern Matrix^a

	Component		
	1	2	3
I quiver with excitement when thinking about designing my next experiment	.799		
I like control conditions	.794		
I enjoy sitting in the park contemplating whether to use participant observation in my next experiment	.788		
Thinking about Bonferroni corrections gives me a tingly feeling in my groin	.745		
Designing experiments is fun	.715		
I calculate 3 ANOVAs in my head before getting out of bed every morning	.682		
I memorize probability values for the F-distribution	.669		
I once woke up in the middle of a vegetable patch hugging a turnip that I'd mistakenly dug up thinking it was Roy's largest root	.623		
I tried to build myself a time machine so that I could go back to the 1930s and follow Fisher around on my hands and knees licking the floor on which he'd just trodden	.620		
I worship at the shrine of Pearson	.615		
Thinking about whether to use repeated or independent measures thrills me	.583		
Helping others to understand Sums of Squares is a great feeling	.568		
I soil my pants with excitement at the mere mention of Factor Analysis	.542		
I like it when people tell me I've helped them to understand factor rotation	.535		
I could spend all day explaining statistics to people	.443		
I'd rather think about appropriate dependent variables than go to the pub	.437		
I like to help students		.618	
If I had a big gun I'd shoot all the students I have to teach		-.560	
Teaching others makes me want to swallow a large bottle of bleach because the pain of my burning oesophagus would be light relief in comparison		-.531	
Standing in front of 300 people in no way makes me lose control of my bowels		-.519	
I spend lots of time helping students	.406	.515	
I love teaching		.449	
Passing on knowledge is the greatest gift you can bestow an individual			.719
I still live with my mother and have little personal hygiene			.687
I often spend my spare time talking to the pigeons ... and even they die of boredom			.680
My cat is my only friend			.536
People fall asleep as soon as I open my mouth to speak			.441
I love teaching because students have to pretend to like me or they'll get bad marks		.418	

Extraction Method: Principal Component Analysis.
 Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Looking at the pattern matrix (and using loadings greater than .4 as recommended by Stevens) we see the following pattern:

Factor 1:

- Q 22. I quiver with excitement when thinking about designing my next experiment
- Q 8. I like control conditions
- Q 17. I enjoy sitting in the park contemplating whether to use participant observation in my next experiment
- Q 21. Thinking about Bonferroni corrections gives me a tingly feeling in my groin
- Q 13. Designing experiments is fun
- Q 9. I calculate 3 ANOVAs in my head before getting out of bed every morning
- Q 3. I memorize probability values for the F-distribution
- Q 1. I once woke up in the middle of a vegetable patch hugging a turnip that I'd mistakenly dug up thinking it was Roy's largest root

- Q 24. I tried to build myself a time machine so that I could go back to the 1930s and follow Fisher around on my hands and knees licking the floor on which he'd just trodden
- Q 4. I worship at the shrine of Pearson
- Q 16. Thinking about whether to use repeated or independent measures thrills me
- Q 7. Helping others to understand Sums of Squares is a great feeling
- Q 15. I soil my pants with excitement at the mere mention of Factor Analysis
- Q 11. I like it when people tell me I've helped them to understand factor rotation
- Q 10. I could spend all day explaining statistics to people
- Q 14. I'd rather think about appropriate dependent variables than go to the pub

Factor 2:

- Q 19. I like to help students
- Q 2. If I had a big gun I'd shoot all the students I have to teach (note negative weight)
- Q 6. Teaching others makes me want to swallow a large bottle of bleach because the pain of my burning oesophagus would be light relief in comparison (note negative weight)
- Q 18. Standing in front of 300 people in no way makes me lose control of my bowels (note negative weight)
- Q 26. I spend lots of time helping students
- Q 25. I love teaching

Factor 3:

- Q 5. I still live with my mother and have little personal hygiene
- Q 23. I often spend my spare time talking to the pigeons ... and even they die of boredom
- Q 28. My cat is my only friend
- Q 12. People fall asleep as soon as I open my mouth to speak
- Q 27. I love teaching because students have to pretend to like me or they'll get bad marks

No Factor:

- Q 20. Passing on knowledge is the greatest gift you can bestow an individual

This factor is a lot clearer cut: Factor 1 relates to a love of methods and statistics, Factor 2 to a love of teaching, and factor 3 to an absence of normal social skills. This doesn't support the original four factor model suggested because the data indicate that love of methods and statistics can't be separated (if you love one you love the other).