

### Example 3: CTT Reliability and Items Analysis in R, STATA, SPSS, and SAS (complete syntax and output available electronically, as results differ slightly across programs)

The data from this example come from Study 2 of this publication (i.e., these are real data, so they are not provided):

Summers, J. A., Hoffman, L., Marquis, J., Turnbull, A. P., Poston, D. P., & Nelson, L. G. L. (2005). [Measuring the quality of family-professional partnerships in special education services](#). *Exceptional Children*, 72(1), 65–81.

In this study (the second administration of these items), we measured the importance of various aspects of parent–professional partnerships for families who have children with disabilities. We begin with two subscales that were identified and refined through exploratory factor analysis in a previous study, entitled Child (11 items) and Family (10 items). Each item had responses ranging from 1 to 5. For illustration, we will examine the child scale items using STATA and R and the family scale items using SPSS and SAS. Note that I am deliberately using all available cases (which is an option within STATA, SAS, and R) to preserve the most information possible.

#### STATA Syntax for 11-Item Child Subscale ([STATA documentation for alpha here](#))

```
display "11-item Child Subscale"
display "Descriptives and Correlations using All Available Cases"
summarize pi5 pi6 pi7 pi8 pi9 pi10 pi11 pi12 pi13 pi14 pi15
pwcrr      pi5 pi6 pi7 pi8 pi9 pi10 pi11 pi12 pi13 pi14 pi15
```

#### R Syntax and Output for 11-item Child Subscale ([R documentation for psych package here](#))

```
# Create object for 11 child items
child11vars = c("pi5","pi6","pi7","pi8","pi9","pi10","pi11","pi12","pi13","pi14","pi15")
# Create a data frame with only these 11 variables
child11Data = Example3[child11vars]
```

```
print("11-Item Child Subscale")
print("Descriptives and Correlations using All Available Cases")
describe(x=child11Data)
cor(x=child11Data, use="pairwise.complete.obs", method="pearson")
```

What do these item means indicate about item severity (aka, item easiness)?

	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
pi5	1	187	4.40	0.88	5	4.55	0	1	5	4	-1.53	2.25	0.06
pi6	2	187	4.71	0.66	5	4.87	0	1	5	4	-2.41	6.12	0.05
pi7	3	186	4.73	0.63	5	4.87	0	1	5	4	-2.89	9.85	0.05
pi8	4	177	4.43	0.92	5	4.59	0	1	5	4	-1.69	2.69	0.07
pi9	5	185	4.40	0.86	5	4.55	0	1	5	4	-1.47	1.92	0.06
pi10	6	188	4.34	0.82	5	4.44	0	1	5	4	-0.98	0.28	0.06
pi11	7	187	4.74	0.65	5	4.91	0	1	5	4	-2.79	8.33	0.05
pi12	8	186	4.56	0.74	5	4.71	0	1	5	4	-1.70	2.75	0.05
pi13	9	187	4.61	0.71	5	4.77	0	1	5	4	-1.85	3.45	0.05
pi14	10	184	4.57	0.74	5	4.72	0	2	5	3	-1.49	1.02	0.05
pi15	11	184	4.85	0.52	5	5.00	0	1	5	4	-4.09	19.52	0.04

#### Pearson Correlations (after using Conditional Formatting + Custom Number Format in Excel)

Child	pi5	pi6	pi7	pi8	pi9	pi10	pi11	pi12	pi13	pi14	pi15
pi5	1.00	.50	.36	.48	.34	.43	.46	.47	.43	.41	.44
pi6	.50	1.00	.57	.55	.39	.37	.46	.52	.49	.37	.62
pi7	.36	.57	1.00	.47	.43	.47	.59	.57	.41	.38	.65
pi8	.48	.55	.47	1.00	.51	.52	.49	.57	.40	.31	.46
pi9	.34	.39	.43	.51	1.00	.54	.55	.70	.62	.42	.46
pi10	.43	.37	.47	.52	.54	1.00	.54	.60	.50	.54	.48
pi11	.46	.46	.59	.49	.55	.54	1.00	.62	.57	.42	.54
pi12	.47	.52	.57	.57	.70	.60	.62	1.00	.72	.51	.61
pi13	.43	.49	.41	.40	.62	.50	.57	.72	1.00	.51	.62
pi14	.41	.37	.38	.31	.42	.54	.42	.51	.51	1.00	.52
pi15	.44	.62	.65	.46	.46	.48	.54	.61	.62	.52	1.00

## STATA Syntax and Output for Item Discrimination and Reliability Statistics

```
display "Item Discriminations and Alpha Reliability using All Available Cases"
alpha pi5 pi6 pi7 pi8 pi9 pi10 pi11 pi12 pi13 pi14 pi15, item // can add std
```

Item	Obs	Sign	item-test correlation	item-rest correlation	average interitem covariance	alpha
PI5	187	+	0.6674	0.5706	.2661626	0.9080
PI6	187	+	0.7054	0.6417	.2753045	0.9035
PI7	186	+	0.7067	0.6468	.2767228	0.9031
PI8	177	+	0.7281	0.6391	.2584227	0.9048
PI9	185	+	0.7451	0.6689	.2583196	0.9021
<b>PI10</b>	188	+	0.7517	<b>0.6808</b>	.2598782	<b>0.9011</b>
PI11	187	+	0.7583	0.7047	.2707859	0.9001
PI12	186	+	0.8512	0.8101	.2553623	0.8941
PI13	187	+	0.7631	0.7046	.2662449	0.8997
<b>PI14</b>	184	+	0.6618	<b>0.5818</b>	.2735985	<b>0.9060</b>
PI15	184	+	0.7588	0.7168	.2800356	0.9017
Test scale					.2673433	<b>0.9103</b> → overall alpha

Item-rest correlation  
= discrimination

The **alpha** column  
gives what alpha  
would be if that item  
were removed →  
"alpha if deleted"

**Large values**  
**indicate bad items**  
(i.e., alpha would  
improve without it)

Label

```
pi5 Help you gain skills or information to get what your child needs.
pi6 Have the skills to help your child succeed.
pi7 Provide services that meet the individual needs of your child.
pi8 Speak up for your child's best interests when working with other service providers.
pi9 Let you know about the good things your child does.
pi10 Are available when you need them.
pi11 Treat your child with dignity.
pi12 Build on your child's strengths.
pi13 Value your opinion about your child's needs.
pi14 Are honest, even when they have bad news.
pi15 Keep your child safe when your child is in their care.
```

## R Syntax and Output for Item Discrimination and Reliability Statistics

```
print("11-Item Child Subscale")
print("Item Discriminations and Alpha Reliability using All Available Cases")
print(alpha(x=child11Data, use="pairwise"), digits=3)
```

```
raw_alpha std.alpha G6(smc) average_r S/N ase mean sd median_r
0.91      0.92      0.92      0.5 11 0.0095 4.6 0.54 0.49
```

Reliability if an item is dropped:

```
raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
pi5      0.908      0.913      0.920      0.513 10.54 0.0098 0.00830 0.517
pi6      0.903      0.910      0.915      0.503 10.10 0.0103 0.00843 0.495
pi7      0.903      0.909      0.913      0.500 9.99 0.0103 0.00807 0.495
pi8      0.905      0.911      0.917      0.505 10.19 0.0102 0.00865 0.501
pi9      0.902      0.909      0.915      0.499 9.96 0.0105 0.00754 0.493
pi10     0.901      0.908      0.915      0.498 9.91 0.0106 0.00913 0.488
pi11     0.900      0.907      0.915      0.492 9.70 0.0107 0.00898 0.486
pi12     0.894      0.902      0.908      0.478 9.16 0.0113 0.00651 0.472
pi13     0.900      0.906      0.911      0.492 9.69 0.0107 0.00750 0.488
pi14     0.906      0.913      0.919      0.511 10.46 0.0100 0.00783 0.495
pi15     0.902      0.905      0.911      0.489 9.58 0.0105 0.00832 0.488
```

The **raw\_alpha**  
column gives what  
alpha would be if that  
item were removed  
→ "alpha if deleted"

**Large values**  
**indicate bad items**  
(i.e., alpha would  
improve without it)

```

Item statistics
      n raw.r std.r r.cor r.drop mean  sd
pi5  187 0.667 0.655 0.602  0.575 4.40 0.877
pi6  187 0.705 0.713 0.681  0.638 4.71 0.659
pi7  186 0.707 0.729 0.704  0.650 4.73 0.626
pi8  177 0.728 0.701 0.664  0.633 4.43 0.915
pi9  185 0.745 0.732 0.705  0.669 4.40 0.861
pi10 188 0.752 0.740 0.708  0.682 4.34 0.822
pi11 187 0.758 0.770 0.742  0.711 4.74 0.646
pi12 186 0.851 0.849 0.846  0.810 4.56 0.742
pi13 187 0.763 0.771 0.757  0.709 4.61 0.705
pi14 184 0.662 0.665 0.618  0.584 4.57 0.744
pi15 184 0.759 0.787 0.771  0.722 4.85 0.521

```

r.drop = Item–rest correlation = discrimination

For help understanding the other columns,  
see [this other example](#) I found helpful

## R Syntax and Output for Item Discrimination and Reliability Statistics after Revision

```

# Create object for 9 child items removing items 10 and 14
child9vars = c("pi5","pi6","pi7","pi8","pi9","pi11","pi12","pi13","pi15")
# Create a data frame with only these 11 variables
child9Data = Example3[child9vars]

print("9-Item Child Subscale - Drop Items 10 and 14")
print("Item Discriminations and Alpha Reliability using All Available Cases")
print(alpha(x=child9Data, use="pairwise"), digits=3)

```

```

raw_alpha std.alpha G6(smc) average_r S/N ase mean sd median_r
0.897      0.905 0.912      0.515 9.57 0.0111 4.6 0.546 0.494

```

Reliability if an item is dropped: (Btw, I concatenated the r.drop column myself)

```

raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r r.drop
pi5      0.896 0.903 0.909 0.539 9.34 0.0112 0.00795 0.548 0.561
pi6      0.886 0.896 0.900 0.518 8.59 0.0123 0.00994 0.491 0.661
pi7      0.887 0.896 0.897 0.518 8.59 0.0122 0.00855 0.494 0.652
pi8      0.890 0.898 0.903 0.525 8.83 0.0120 0.01010 0.532 0.636
pi9      0.887 0.897 0.901 0.521 8.69 0.0123 0.00737 0.505 0.654
pi11     0.883 0.893 0.899 0.510 8.31 0.0127 0.01014 0.489 0.707
pi12     0.874 0.886 0.889 0.492 7.75 0.0137 0.00693 0.478 0.803
pi13     0.883 0.893 0.894 0.511 8.36 0.0127 0.00742 0.494 0.697
pi15     0.885 0.891 0.895 0.506 8.19 0.0125 0.00896 0.490 0.717

```

## STATA Syntax and Output for Item Discrimination and Reliability Statistics after Revision

```

display "9-item Child Subscale -- Drop Items 10 and 14"
display "Item Discriminations and Alpha Reliability Using All Available Cases"
alpha pi5 pi6 pi7 pi8 pi9 pi11 pi12 pi13 pi15, label item

```

Item	Obs	Sign	item-test correlation	item-rest correlation	average interitem covariance	alpha
pi5	187	+	0.6749	0.5548	.267477	0.8960
pi6	187	+	0.7380	0.6652	.2749664	0.8859
pi7	186	+	0.7196	0.6473	.2788524	0.8869
pi8	177	+	0.7467	0.6401	.2557001	0.8896
pi9	185	+	0.7503	0.6555	.2575651	0.8872
pi11	187	+	0.7656	0.6999	.2717514	0.8828
pi12	186	+	0.8539	0.8031	.2526514	0.8742
pi13	187	+	0.7645	0.6911	.2668239	0.8828
pi15	184	+	0.7633	0.7118	.2836274	0.8851
Test scale					.2676971	0.8970 → overall alpha

Item–rest correlation  
= discrimination

The **alpha** column  
gives what alpha  
would be if that item  
were removed →  
"alpha if deleted"  
(large = bad)

The remaining 9 items seem to be ok—there are no obvious problems with item discrimination, and the items all measure some aspect of support for one's child. Let's see what happens with the other subscale, to which the deleted family-related items 10 and 14 will now be added...

**SPSS Syntax for 12-Item Family Subscale ([SPSS documentation about RELIABILITY here](#)):**

```

TITLE "12-item Family Subscale".
ECHO "Descriptives, Correlations, and Reliability using All Available Cases".
DESCRIPTIVES VARIABLES = pi10 pi14 pi16 pi17 pi18 pi19 pi20 pi21 pi22 pi23 pi24 pi25.
RELIABILITY
  /VARIABLES = pi10 pi14 pi16 pi17 pi18 pi19 pi20 pi21 pi22 pi23 pi24 pi25
  /SCALE(family12) = ALL
  /MODEL = ALPHA
  /STATISTICS = DESCRIPTIVE CORRELATIONS SCALE
  /SUMMARY = TOTAL .

```

**SAS Syntax and Output for 12-Item Family Subscale ([SAS documentation about ALPHA here](#)):**

```

TITLE1 "12-item Family Subscale";
TITLE2 "Descriptives, Correlations, and Reliability using All Available Cases";
PROC CORR DATA=work.partner ALPHA OUT=work.FamCorrs; * Save correlations to dataset;
  VAR pi10 pi14 pi16 pi17 pi18 pi19 pi20 pi21 pi22 pi23 pi24 pi25;
RUN; TITLE1; TITLE2;
* Export correlations to excel for formatting;
PROC EXPORT DATA=work.ChildCorrs OUTFILE="&filesave.\ExportedCorrs.xlsx"
  DBMS=XLSX REPLACE; SHEET="FamilyCorrs"; RUN;

```

**Item Descriptive Statistics**

Simple Statistics							
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
PI10	188	4.34043	0.82154	816.00000	1.00000	5.00000	pi10 Are available when you need them.
PI14	184	4.56522	0.74371	840.00000	2.00000	5.00000	pi14 Are honest, even when they have bad news.
PI16	185	4.09730	1.00068	758.00000	1.00000	5.00000	pi16 Use words that you understand.
PI17	184	4.19565	0.89001	772.00000	1.00000	5.00000	pi17 Plan meetings at times and places that are good for you and your family.
PI18	184	4.39674	0.81662	809.00000	1.00000	5.00000	pi18 Return your messages.
PI19	185	4.36216	0.76163	807.00000	3.00000	5.00000	pi19 Keep appointments with your child and family.
PI20	184	4.42391	0.83285	814.00000	1.00000	5.00000	pi20 Protect your family's privacy.
PI21	183	4.44262	0.78147	813.00000	1.00000	5.00000	pi21 Show respect for your family's values and beliefs.
PI22	183	4.39891	0.77700	805.00000	1.00000	5.00000	pi22 Listen without judging your child or family.
PI23	184	4.53261	0.71596	834.00000	1.00000	5.00000	pi23 Are dependable.
PI24	184	4.54891	0.71502	837.00000	1.00000	5.00000	pi24 Pay attention to what you have to say.
PI25	184	4.24457	0.87464	781.00000	1.00000	5.00000	pi25 Are friendly.

**Pearson Correlations (after using Conditional Formatting + Custom Number Format in Excel)**

Family	PI10	PI14	PI16	PI17	PI18	PI19	PI20	PI21	PI22	PI23	PI24	PI25
PI10	1.00	.54	.49	.62	.58	.57	.31	.57	.51	.53	.49	.48
PI14	.54	1.00	.31	.42	.46	.40	.17	.44	.35	.48	.50	.39
PI16	.49	.31	1.00	.62	.45	.67	.46	.49	.48	.46	.47	.46
PI17	.62	.42	.62	1.00	.65	.63	.42	.64	.51	.52	.57	.57
PI18	.58	.46	.45	.65	1.00	.69	.36	.57	.55	.52	.58	.51
PI19	.57	.40	.67	.63	.69	1.00	.47	.58	.52	.46	.48	.54
PI20	.31	.17	.46	.42	.36	.47	1.00	.47	.43	.36	.23	.33
PI21	.57	.44	.49	.64	.57	.58	.47	1.00	.65	.54	.58	.56
PI22	.51	.35	.48	.51	.55	.52	.43	.65	1.00	.52	.57	.39
PI23	.53	.48	.46	.52	.52	.46	.36	.54	.52	1.00	.68	.46
PI24	.49	.50	.47	.57	.58	.48	.23	.58	.57	.68	1.00	.43
PI25	.48	.39	.46	.57	.51	.54	.33	.56	.39	.46	.43	1.00

**Item Discrimination and Reliability Statistics**

Cronbach Coefficient Alpha	
Variables	Alpha
Raw	<b>0.919916</b>
Standardized	0.921630

**SPSS output (not shown):** Corrected item–total correlation = discrimination;  
Cronbach's Alpha if deleted is labeled directly

**SAS output underlined below:**

Raw variable correlation with total = item–rest correlation = discrimination  
Alpha = alpha-if-deleted (large = bad)

Cronbach Coefficient Alpha with Deleted Variable					
Deleted Variable	Raw Variables		Standardized Variables		Label
	<u>Correlation with Total</u>	<u>Alpha</u>	<u>Correlation with Total</u>	<u>Alpha</u>	
PI10	0.711158	0.911409	0.705486	0.913735	pi10 Are available when you need them.
PI14	<b>0.546106</b>	<b>0.918109</b>	<b>0.543628</b>	<b>0.920493</b>	<b>pi14 Are honest, even when they have bad news.</b>
PI16	0.662472	0.914501	0.660495	0.915638	pi16 Use words that you understand.
PI17	0.772565	0.908476	0.769371	0.911001	pi17 Plan meetings at times and places that are good for you and your family.
PI18	0.731046	0.910555	0.734015	0.912519	pi18 Return your messages.
PI19	0.757937	0.909720	0.750262	0.911823	pi19 Keep appointments with your child and family.
PI20	<b>0.470009</b>	<b>0.921769</b>	<b>0.484819</b>	<b>0.922889</b>	<b>pi20 Protect your family's privacy.</b>
PI21	0.756793	0.909628	0.760158	0.911397	pi21 Show respect for your family's values and beliefs.
PI22	0.672468	0.913134	0.675767	0.914994	pi22 Listen without judging your child or family.
PI23	0.678667	0.913123	0.682219	0.914721	pi23 Are dependable.
PI24	0.685460	0.912873	0.690390	0.914375	pi24 Pay attention to what you have to say.
PI25	0.630974	0.915071	0.629229	0.916949	pi25 Are friendly.

## SPSS Syntax for Item Discrimination and Reliability Statistics after Revision

```
TITLE "9-item Family Subscale -- Drop Items 17, 18, and 19".
RELIABILITY
  /VARIABLES = pi10 pi14 pi16 pi20 pi21 pi22 pi23 pi24 pi25
  /SCALE(family9) = ALL
  /MODEL = ALPHA
  /STATISTICS = DESCRIPTIVE CORRELATIONS SCALE
  /SUMMARY = TOTAL .
```

## SAS Syntax and Output for Item Discrimination and Reliability Statistics after Revision

```
TITLE1 "9-item Family Subscale -- Drop Items 17, 18, 19";
TITLE2 "Descriptives, Correlations, and Reliability using All Available Cases";
PROC CORR DATA=work.Example3 ALPHA;
  VAR pi10 pi14 pi16 pi20 pi21 pi22 pi23 pi24 pi25;
RUN; TITLE1; TITLE2;
```

Cronbach Coefficient Alpha	
Variables	Alpha
Raw	0.880650
Standardized	0.884636

**SPSS output (not shown):** Corrected item–total correlation = discrimination;  
Cronbach's Alpha if deleted is labeled directly

**SAS output below:**

Raw variable correlation with total = item–rest correlation = discrimination  
Alpha = alpha-if-deleted (large = bad)

Cronbach Coefficient Alpha with Deleted Variable					
Deleted Variable	Raw Variables		Standardized Variables		Label
	<u>Correlation with Total</u>	<u>Alpha</u>	<u>Correlation with Total</u>	<u>Alpha</u>	
<b>PI10</b>	0.685695	0.862388	0.680122	0.868106	pi10 Are available when you need them.
<b>PI14</b>	0.539910	0.874580	0.539446	0.879847	pi14 Are honest, even when they have bad news.
<b>PI16</b>	0.622190	0.870000	0.619892	0.873193	pi16 Use words that you understand.
<b>PI20</b>	0.452268	0.882623	0.461485	0.886146	pi20 Protect your family's privacy.
<b>PI21</b>	0.751601	0.857085	0.754751	0.861677	pi21 Show respect for your family's values and beliefs.
<b>PI22</b>	0.670314	0.864026	0.673817	0.868642	pi22 Listen without judging your child or family.
<b>PI23</b>	0.693632	0.862935	0.698980	0.866494	pi23 Are dependable.
<b>PI24</b>	0.675898	0.864313	0.683611	0.867808	pi24 Pay attention to what you have to say.
<b>PI25</b>	0.601005	0.870156	0.599113	0.874927	pi25 Are friendly.

The remaining 9 items seem to be ok—although they vary in discrimination, those with lower item–remainder correlations were thought to measure different aspects of the construct that would limit construct validity if removed... so we called it done! And the article has since been cited 305 times...