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Using JMP® and R Integration to Assess Inter-rater Reliability in Diagnosing Penetrating Abdominal Injuries from MDCT Radiological Imaging

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Disclaimer

- The views expressed in this presentation are the presenter's and do not represent the views of the Social Security Administration, The University of Maryland Medical Center, or SAS Institute, Inc.

Presentation Overview

Fleiss' kappa (in the JMP Attribute Gauge platform using ordinal rating scales) helped assess **inter-rater agreement** between independent radiologists who diagnosed patients with penetrating abdominal injuries.

Fleiss' kappa poorly estimates inter-rater reliability when disagreement distributions between raters vary widely and have different magnitudes with multiple raters.

Krippendorff's alpha better differentiates between raters disagreements for various sample sizes; and estimates judgments, with or without missing data, across multiple measurement scales (binary, nominal, ordinal, interval, and ratio) for multiple raters.

Krippendorff's alpha, thoughnot available in JMP, is available in the R open-source statistical programming language. JMP connects to R via JSL to execute R commands and exchange data.

This presentation will demonstrate how JMP and R integration takes advantage of the powerful capabilities in both tools. Combining JMP and R helps users gain more insight and get better analytic results. Results helped radiologists discern which imaging signs detected injuries from signs that needed improved detection training.

Agenda

- Demonstrate JMP and R Integration Computing Krippendorff Alpha using Example from Penetrating Gastrointestinal Tract/Bowel Injury (PBI) Case Study
- Summary and Conclusions
- Q & A

Trauma Radiology Case Study

- Missed gastrointestinal (GI) tract – Bowel injuries lead to significant morbidity and mortality among trauma patients
- This case study sought to assess the degree of agreement three independent radiologists had interpreting signs that indicated Penetrating GI tract-Bowel Injury (PBI)
- Also, find out if any sign(s) gave the best indication of PBI to any degree of sensitivity, specificity, and diagnostic accuracy

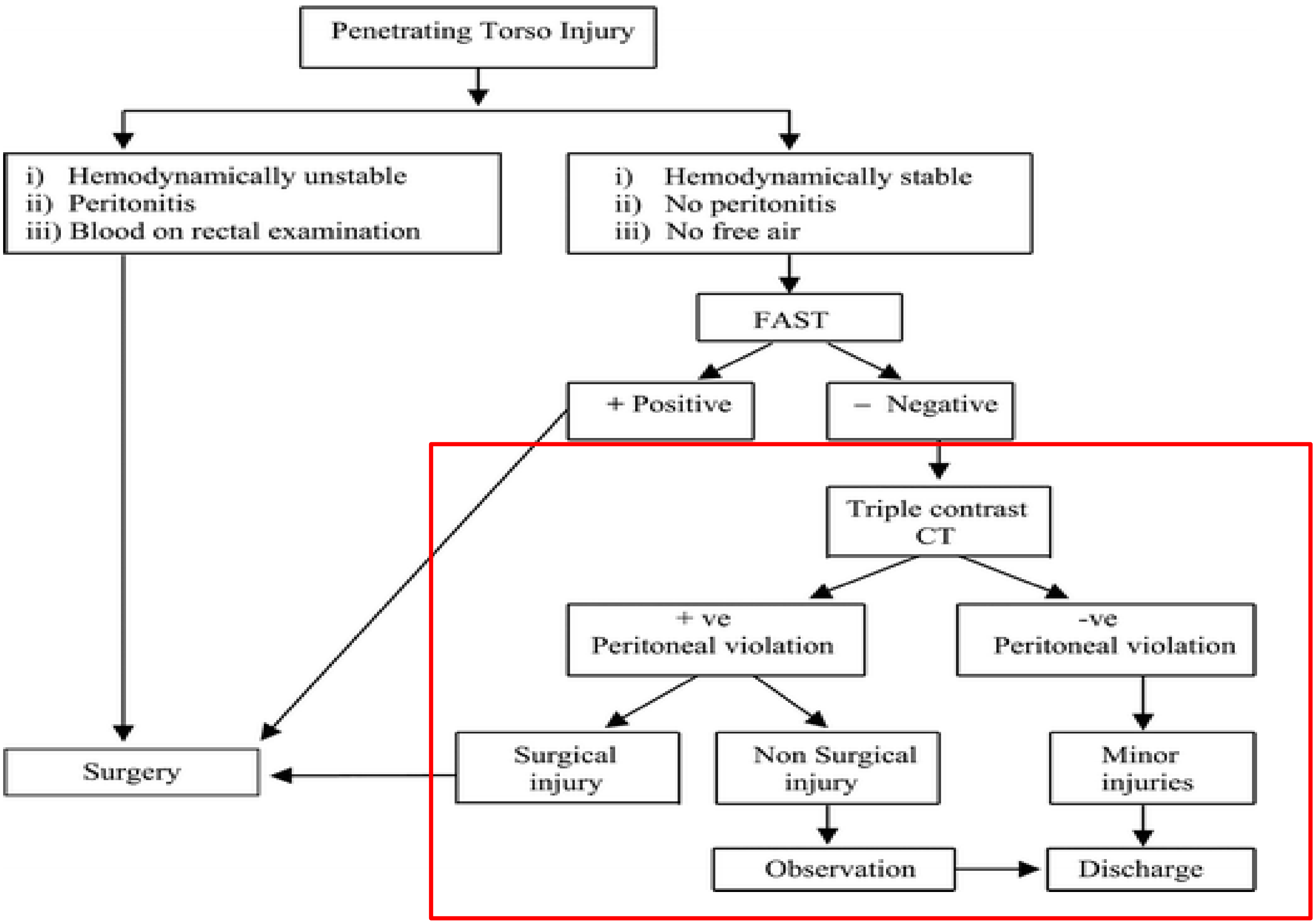
Materials and Methods cont.

- CT images of 171 patients underwent MDCT imaging for surgery (77/171, 45.0%) or clinical follow-up (94/171, 55.0%) between October, 2011 – April, 2013 at the University of Maryland Medical Center’s (UMMC) Shock Trauma Center
- Images were interpreted by three independent radiologists, (one attending radiologist and two secondary readers)
- Each radiologist interpreted each patient scan and recorded findings on dedicated worksheets, blind to each other’s imaging, clinical data, or patient’s management outcomes

Materials and Methods (Design and Data Collection)

- CT images were evaluated for 17 individual signs (Q1-Ctoverall) believed to indicate GI tract injury using a 5-point confidence scale (1-definitely absent, 2-possibly present but unlikely, 3-equivocal, 4-likely present, 5-definitely present).
- Attending trauma surgeons and radiologist (reference standard) determined the presence or absence of GI tract injury intra-operatively (1=BI injury, 0 = No BI injury)
- All radiologists scored a binary variable indicating whether the patient required an operative management specifically for GI tract injury or not

Triple-Contrast Imaging Algorithm (FAST) for Stable Patients with Penetrating Trauma (Reprinted with permission from the Radiological Society of North America)



Key terms

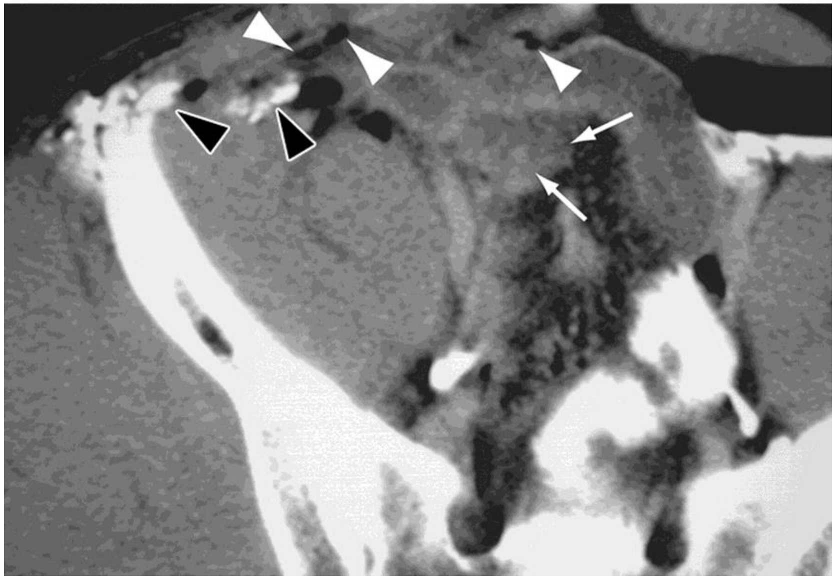
Focused **A**ssessment with **S**onography for **T**rauma (FAST): Rapid Sonographic, Ultrasound, MDCT Examination used by radiologists, surgeons, emergency physicians and certain paramedics to screen for blood around the heart or abdominal organs after trauma.

JMP Column	Sign	Peritoneum – Membrane (thin tissues) that lines the abdomen and inner abdominal organs
Q1	Peritoneal violation	Indirect sign of injury to the peritoneum
Q2	Retroperitoneal violation	Indirect sign of injury to retro-peritoneal colon
Q3a	Free gas at wound track	Indirect sign of free intraperitoneal/retroperitoneal gas *adjacent to* the GI injury site
Q3b	Free gas away from wound track	Indirect sign of free intraperitoneal/retroperitoneal gas *remote to* the GI injury site
Q4	Intramural gas	Direct sign of intramural air
Q5	Leakage of luminal content	Direct sign bleeding into GI lumen (inside space of intestinal tubular structure)
Q6	Leakage of oral/rectal contrast	Direct Sign of leakage of enteric contrast material
Q7	Discontinuity of bowel wall	Direct sign of GI
Q8	Bowel wall thickening	Direct sign of peritoneal thickening or enhancement
Q9	Free fluid	Indirect sign of free intraperitoneal fluid
Q10	Mesenteric hematoma	Indirect sign of blood leakage into intestinal organs
Q11	Active mesenteric bleeding	Indirect sign of extensive hemorrhaging into intestinal organs
Q12	Signs of peritonitis	Indirect sign of peritoneum inflammation
Q13	Signs of solid organ injury	Indirect sign of injuries to other abdominal organs
Q14	Intraluminal bleeding	Direct sign of bleeding into GI lumen
Q15	Wound track extending up to bowel	Direct sign of visible penetrating wound track hemorrhage, air, and/or ballistic fragments that extended up to the GI wall

Materials and Methods (Analysis)

- Inter-observer agreement was evaluated by computing weighted kappa statistics using Fleiss' method from JMP®'s Analyze > Quality and Process > Attribute Gauge platform. Kappa values above 0.80 indicated near complete agreement, 0.61-0.80 strong. 0.41-0.60 moderate, 0.21-0.40 fair, and less than 0.20 poor agreement among radiologists
- Krippendorff's alpha was computed from R to give a more generalized measure of inter-rater reliability than Fleiss' kappa

Example of Penetrating Bowel Injury (PBI)
(Reprinted with permission from the Radiological Society of North America)



Transverse CT scan shows a wound track that extends to the bowel in a 33-year-old man shot in the right hemipelvis. Note bullet and bone fragments (black arrowheads) outlining the wound track that extends to a loop of small bowel (Q15). Free intraperitoneal air (Q3a, Q3b - white arrowheads) and fluid (Q9-arrows) are seen from peritoneal violation (Q1). An injury to the ileum was confirmed surgically.

Penetrating Torso Trauma: Triple-Contrast Helical CT in Peritoneal Violation and Organ Injury—A Prospective Study in 200 Patients[1]

K. Shanmuganathan, MD
Stuart E. Mirvis, MD
William C. Chiu, MD
Karen L. Killeen, MD[2]
Gerald J. F. Hogan, MD
Thomas M. Scalea, MD

Index terms:
Computed tomography (CT), helical, 78.12115
Computed tomography (CT), multi–detector row, 78.12112
Emergency radiology
Trauma

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Radiology 2004; 231:775–784

Selected Records of the Data

Surgical Subset of pbi 11 for Mel July_02_2013 - JMP

File Edit Tables Rows Cols DOE Analyze Graph Tools Add-Ins View Window Help

21/0 Cols

231/0

	No	BI	Readernumber	Q1	Q2	Q3a	Q3b	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Ctoverall	Numeric_BI
1	1	Y	1	5	1	1	5	1	1	1	1	1	5	1	1	1	1	1	1	3	1
2	1	Y	2	5	1	1	5	1	1	1	1	1	4	1	1	1	1	1	5	5	1
3	1	Y	3	5	1	5	5	1	2	1	1	1	5	2	1	1	1	3	3	2	1
4	2	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
5	2	N	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
6	2	N	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
7	3	N	1	5	5	5	1	1	1	•	1	1	1	1	1	1	5	1	1	2	0
8	3	N	2	5	1	1	1	1	1	•	3	5	5	5	1	1	5	3	4	4	0
9	3	N	3	5	5	5	1	1	1	•	1	1	5	1	1	1	5	1	1	2	0
10	4	N	1	5	1	1	1	1	1	1	1	1	5	1	1	1	5	1	1	1	0
11	4	N	2	5	1	1	1	1	1	1	1	1	5	1	1	1	5	1	1	1	0
12	4	N	3	5	1	1	1	1	1	1	1	1	5	1	1	1	5	1	5	1	0
13	5	N	1	5	1	5	2	1	2	•	2	1	5	2	1	1	5	2	2	2	0
14	5	N	2	5	1	5	5	1	1	•	1	4	5	1	1	2	5	1	4	2	0
15	5	N	3	5	1	5	5	1	2	•	1	2	5	1	1	1	5	1	1	2	0
16	6	Y	1	1	5	5	5	1	1	5	5	5	1	1	1	1	1	1	5	5	1
17	6	Y	2	2	5	5	1	2	4	5	5	5	1	1	1	1	1	3	5	5	1
18	6	Y	3	1	5	5	5	1	1	1	1	5	5	1	1	1	1	1	5	4	1
19	7	N	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
20	7	N	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
21	7	N	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0

JSL Script to compute Krippendorff's Alpha using JMP and R Integration

```
/*****************************************************************
  This JMP-R Integration example computes Krippendorff's alpha
  reliability coefficient that measures agreement among different
  raters or measuring instruments drawing distinctions among
  unstructured phenomena or assign computable values to items.

  Alpha emerged from content analysis whenever two or more
  methods of generating data are applied to the same subjects.
  Alpha answers the question of how much the resulting data
  can be trusted to represent something real.

  The R implementation uses the lpSolve and irr library packages
  with the kripp.alpha function with ordinal measures.

  Visit http://en.wikipedia.org/wiki/Krippendorff's_alpha
  for more information.

  Author: Melvin Alexander
  Version: 1, 12Feb14 - Initial coding
  Updates:

*****************************************************************/

R Init() ;
//Open Data Table with Response variable (BI) and Signs (Explanatory variables)
//pbi 11 for Mel July_02_2013 contains all data
dt = Open("G:\Nitima\Surgical Subset of pbi 11 for Mel July_02_2013.jmp",
     Select Columns("No", "Readernumber", "BI", "Q1","Q2", "Q3a", "Q3b", "Q4", "Q5",
     "Q6", "Q7", "Q8", "Q9", "Q10", "Q11", "Q12", "Q13", "Q14", "Q15", "Ctoverall"
     ) ) <<     New Column( "Numeric_BI", Nominal, Format( "Best", 12 ),
        Formula( :BI == "Y" ));

// Form column vectors of signs (Q1-Ctoverall)
col=Column("Q1");
q1mtx = col<<GetAsMatrix;
dt=Current Data Table() ;
q2mtx=Column("Q2")<<GetAsMatrix;
dt=Current Data Table();

< Code removed for the other column vectors >
```

```
//Send JMP vectors to R variables and compute Krippendorff alphas
R Send(q1mtx);
R Submit( "\[
# load lpSolve and irr packages
library (lpSolve)
library (irr)
Q1<-matrix(q1mtx,nrow=3)
Q1alpha <- kripp.alpha(Q1,"ordinal")
# Mel Alexander's adaptation of Mike Gruszczynski's kripp.boot.R code
# Reference: https://github.com/MikeGruz/kripp.boot/blob/master/R/kripp.boot.R
# bootalpha generates bootstrap resamples of krippendorff alphas several times (default iter=100)
bootalpha <- function (x, raters='rows', probs=c(0.025,0.975), iter=100,
                       method=c('nominal','ordinal','interval','ratio'))
               { alphas <- numeric(iter)
                for( i in 1:iter)
                   { alphas[i] <- kripp.alpha(x[,sample(ncol(x),
                    size=ncol(x), replace=TRUE)],method=method)$value
                   }
                   kripp.ci <- quantile(alphas, probs=probs, na.rm=TRUE)
                   boot.stats <- list(mean.alpha=mean(alphas, na.rm=TRUE),
                              upper=kripp.ci[2], lower=kripp.ci[1],
                              alphas=alphas,raters=nrow(x),iter=iter, robs=probs,
                              sealpha = sqrt(var(alphas)/length(alphas)),
                              size=ncol(x))
                   class(boot.stats) <- 'bootalpha'
                   return(boot.stats)
                }
Q1boot <- bootalpha(Q1, iter=1000,  method='ordinal')
# combine the original alpha (nmmoalpha) with the bootstrapped alphas (Q1boot$alphas)
Q1allalphas <- matrix(c(Q1alpha$value, Q1boot$alphas))
#Q1allalphas
# Get the standard error of the median
Q1.median <- sapply(Q1allalphas,median)
Q1semed <- sqrt(var(Q1.median))
# join the original alpha (Q1alpha$value) with the standard error of the median (Q1semed),
# 95% ci alpha values (Q1boot$lower, Q1boot$upper)
Q195ci <- matrix(c(Q1alpha$value, Q1semed, Q1boot$lower, Q1boot$upper), nrow=1)
Q195ci
]\" );
```

JSL Script to compute Krippendorff's Alpha using JMP to R Integration (cont.)

```
R Send(q2mtx);
R Submit( "\[
#library (irr)
Q2<-matrix(q2mtx,nrow=3)
Q2alpha <- kripp.alpha(Q2,"ordinal")
Q2boot <- bootalpha(Q2, iter=1000,  method='ordinal')
#Q2boot
# combine the original alpha (Q2alpha$value) with the bootstrapped alphas (Q2boot$alphas)
Q2allalphas <- matrix(c(Q1alpha$alpha, Q1boot$alphas))
#Qallalphas

# join the original alpha (Q2alpha$value) with the standard error (Q2boot$sealpha)
# 95% ci alpha values (Q2boot$lower, Q2boot$upper)

Q295ci <- matrix(c(Q2alpha$value, Q2boot$sealpha, Q2boot$lower, Q2boot$upper), nrow=1)
Q295ci
]\" );

< Code removed foor the other R Send and Submit commands >
//Collect R krippendorff alphas as JMP variables
Q1alpha95 = R Get (Q195ci) ;
Q2alpha95 = R Get (Q295ci) ;
Q3aalpha95 = R Get (Q3a95ci) ;
Q3balpha95 = R Get (Q3b95ci) ;
Q4alpha95 = R Get (Q495ci) ;
Q5alpha95 = R Get (Q595ci) ;
Q6alpha95 = R Get (Q695ci) ;
Q7alpha95 = R Get (Q795ci) ;
Q8alpha95 = R Get (Q895ci) ;
Q9alpha95 = R Get (Q995ci) ;
Q10alpha95 = R Get (Q1095ci) ;
Q11alpha95 = R Get (Q1195ci) ;
Q12alpha95 = R Get (Q1295ci) ;
Q13alpha95 = R Get (Q1395ci) ;
Q14alpha95 = R Get (Q1495ci) ;
Q15alpha95 = R Get (Q1595ci) ;
Qoallalpha95 = R Get (Qoall95ci) ;

R Term( );
```

```
//Send krippendorff bootstraped alphas from R to a JMP matrix
allalpha = Concat(Q1allalpha,Q2allalpha,Q3aallalpha,Q3ballalpha,Q4allalpha,
        Q5allalpha,Q6allalpha,Q7allalpha,Q8allalpha,Q9allalpha,Q10allalpha,
        Q11allalpha, Q12allalpha,Q13allalpha,Q14allalpha,Q15allalpha,Qoallallalpha
);
// Vertically Concatenate the alphas and 95%ci alpha matrices
alpha95ci = VConcat(Q1alpha95, Q2alpha95,Q3aalpha95, Q3balpha95,
            Q4alpha95, Q5alpha95, Q6alpha95, Q7alpha95, Q8alpha95,
            Q9alpha95, Q10alpha95, Q11alpha95, Q12alpha95,
            Q13alpha95, Q14alpha95, Q15alpha95, Qoallalpha95
            ) ;
//Send krippendorff alphas  and cis from R to a JMP matrix
/*
dtallalpha = As Table(allalpha)<< Set Name("Krippendorff Bootstrapped Alphas");
*/
dt95cialpha = As Table(alpha95ci)<< Set Name("Krippendorff Alpha and 95%CI");
col = Col1 << Set Name("Alpha");
col = Col2 << Set Name("Standard Error of the median") ;
col = Col3 << Set Name("Lower 95% Alpha ");
col = Col4 << Set Name("Upper 95% Alpha ");
/*
// Add Sign column to Data Table in reverse order
Data Table("Krippendorff Alpha") << New Column("Sign", Character, Values({"Q1", "Q2", "Q3a", "Q3b", "Q4",
    "Q5","Q6","Q7","Q8","Q9","Q10","Q11","Q12","Q13","Q14","Q15","Ctoverall"}
)) << Reverse Order ;
*/
// Add Sign column to Data Table and move it to first
dt95cialpha = Data Table ("Krippendorff Alpha and 95%CI") << New Column("Sign",
                  Character, Values({"Q1", "Q2", "Q3a", "Q3b", "Q4",
    "Q5","Q6","Q7","Q8","Q9","Q10","Q11","Q12","Q13","Q14","Q15","Ctoverall"}
)) ;
dt95cialpha = Data Table("Krippendorff Alpha and 95%CI")
            << Get Selected Columns ("Sign")
            << Move Selected Columns({"Sign"}, To First);
```

Selected Signs of 1001 Bootstrapped Krippendorff's Alphas
(First row are the Krippendorff alphas for each sign of the original data)

Krippendorff Bootstrapped Alphas - JMP

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Krippendorff Bo...

Columns (17/0)

Q1, Q2, Q3a, Q3b, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12

Rows

All rows	1,001
Selected	0
Excluded	0
Hidden	0
Labelled	0

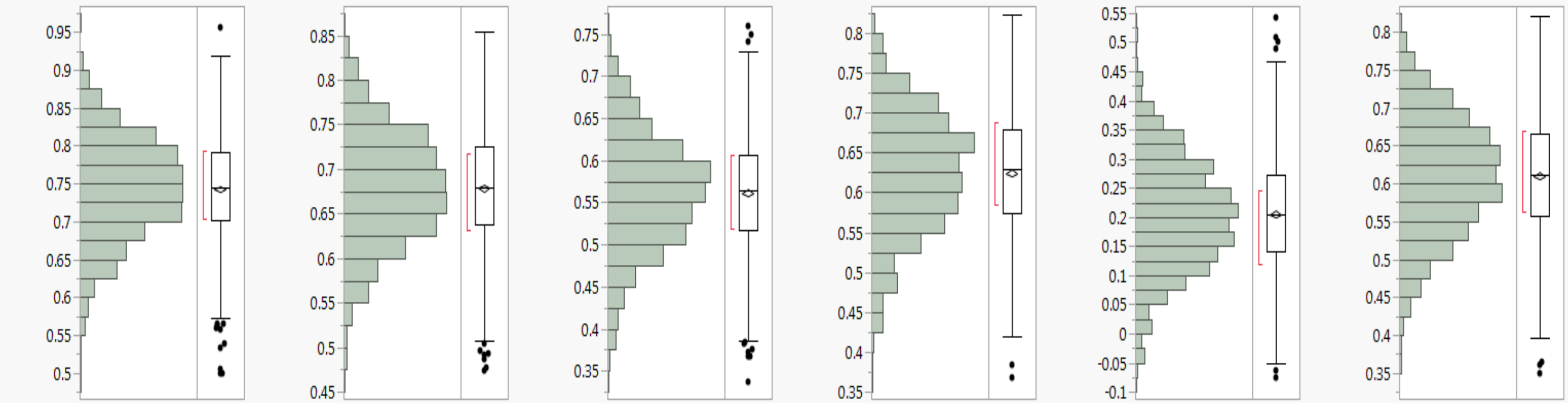
	Q1	Q2	Q3a	Q3b	Q4	Q5	Q6	Q7	Q8
1	0.7503407205	0.6863852424	0.5696314041	0.6282646652	0.2139495116	0.6155022449	0.7821915078	0.4424166103	0.47753041
2	0.7210360746	0.7859200824	0.5046050838	0.6056230326	0.1947785763	0.7059581525	0.8079280009	0.4604220466	0.38977560
3	0.5720361086	0.6482426264	0.514438717	0.6588734576	0.1879729034	0.5646124566	0.7947567094	0.1381087392	0.53865453
4	0.7506966294	0.6023449735	0.6158203202	0.6521212777	0.2025975456	0.5054917158	0.5698358853	0.3346991954	0.43835554
5	0.7715459011	0.6272030508	0.6195849086	0.6861634784	0.1673904465	0.5048999755	0.8252894444	0.5993458945	0.52808689
6	0.6280803851	0.5600545567	0.6716101968	0.6711610727	0.3420326486	0.539202459	0.5018901591	0.4802878074	0.72450041
7	0.7732603879	0.6761144729	0.5274906005	0.7066767284	0.1077347	0.7335028986	0.7750818821	0.3739184774	0.41934101
8	0.7338822678	0.6876724506	0.5193174203	0.6429510506	0.1451848429	0.5748235679	0.8108623581	0.4449492196	0.36478638
9	0.6769203931	0.6227643765	0.7497746122	0.6337941785	0.2846360342	0.457483872	0.8227957925	0.3241417287	0.36150168
10	0.7235056939	0.768018476	0.6630945567	0.7272999747	0.2305584332	0.5848968593	0.7870634607	0.3672754197	0.42915667
11	0.7605945339	0.6635798092	0.5727918574	0.6622085244	0.2106267704	0.6614732251	0.8006302235	0.4187850251	0.30733200
12	0.7708749225	0.682339275	0.5350938842	0.5976630835	0.1321558467	0.5854656389	0.7604468865	0.3719499532	0.58971135
13	0.6372039997	0.6426098698	0.5718887318	0.6707687996	0.1458339579	0.5999384779	0.7190363121	0.4021871538	0.54501838
14	0.7640478029	0.6141551123	0.5221268047	0.7026533601	0.1616578682	0.7105800187	0.9514525139	0.5125407724	0.40452465
15	0.7600176898	0.6494131183	0.6084140732	0.7979545441	0.180615877	0.6792807285	0.8240211237	0.4751102005	0.60664820
16	0.5807408431	0.7718705223	0.6321302269	0.5778995766	0.2933670118	0.6802872078	0.7666736916	0.3665353209	0.48705803
17	0.7805272207	0.6730492708	0.6605950713	0.5793462048	0.3540457742	0.6750115674	0.7197741931	0.4351805292	0.49732229
18	0.6507940291	0.7230874432	0.5974847323	0.444380781	0.2207898559	0.6709899714	0.6418147685	0.5783670043	0.40955700
19	0.7419538518	0.7715424138	0.5384472799	0.6425875489	0.2165720164	0.6810537925	0.7496650449	0.5140910758	0.37511737
20	0.7616445982	0.7040156087	0.4802663329	0.7130578605	0.2429206431	0.7159862525	0.7384735901	0.5340342135	0.50847850
21	0.6912089883	0.5453255004	0.4940759801	0.600797481	0.124466469	0.6323482586	0.7156257938	0.5265215436	0.45387935

Distribution of 1001 Bootstrapped Krippendorff's Alphas for Selected Signs

Krippendorff Bootstrapped Alphas - Distribution - JMP

Distributions

Q1 | Q2 | Q3a | Q3b | Q4 | Q5



Quantiles

		Q1	Q2	Q3a	Q3b	Q4	Q5
100.0%	maximum	0.95507	0.85454	0.75875	0.82261	0.54148	0.82159
99.5%		0.90075	0.82849	0.72719	0.79795	0.4675	0.79638
97.5%		0.86804	0.80499	0.6938	0.76483	0.39243	0.75422
90.0%		0.82549	0.76069	0.65143	0.71807	0.33122	0.71053
75.0%	quartile	0.79146	0.72456	0.60558	0.67876	0.27175	0.66536
50.0%	median	0.74491	0.67844	0.56353	0.62922	0.20336	0.61226
25.0%	quartile	0.70124	0.63746	0.51726	0.5734	0.14105	0.5575
10.0%		0.65457	0.597	0.47748	0.52673	0.08314	0.50642
2.5%		0.60291	0.55119	0.4115	0.46332	0.00848	0.45335
0.5%		0.53852	0.49357	0.37644	0.42489	-0.0396	0.39779
0.0%	minimum	0.49954	0.47455	0.33759	0.36829	-0.0754	0.35008

Summary Statistics

	Q1	Q2	Q3a	Q3b	Q4	Q5
Mean	0.7428761	0.6786516	0.5616076	0.624365	0.2050753	0.6100029
Std Dev	0.067366	0.0642592	0.0685842	0.0761762	0.0967197	0.0786455
Std Err Mean	0.0021292	0.002031	0.0021677	0.0024077	0.003057	0.0024857
Upper 95% Mean	0.7470544	0.6826371	0.5658614	0.6290897	0.2110742	0.6148807
Lower 95% Mean	0.7386978	0.674666	0.5573537	0.6196403	0.1990764	0.605125
N	1001	1001	1001	1001	1001	1001

Krippendorff's Alpha Data Table with 95% Confidence Intervals Computed from 1000 Bootstrapped Resamples

Krippendorff Alpha and 95%CI - JMP

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Krippendorff Alpha and 95%CI

Stack Alphas and 95% CIs and plo

Columns (5/0)

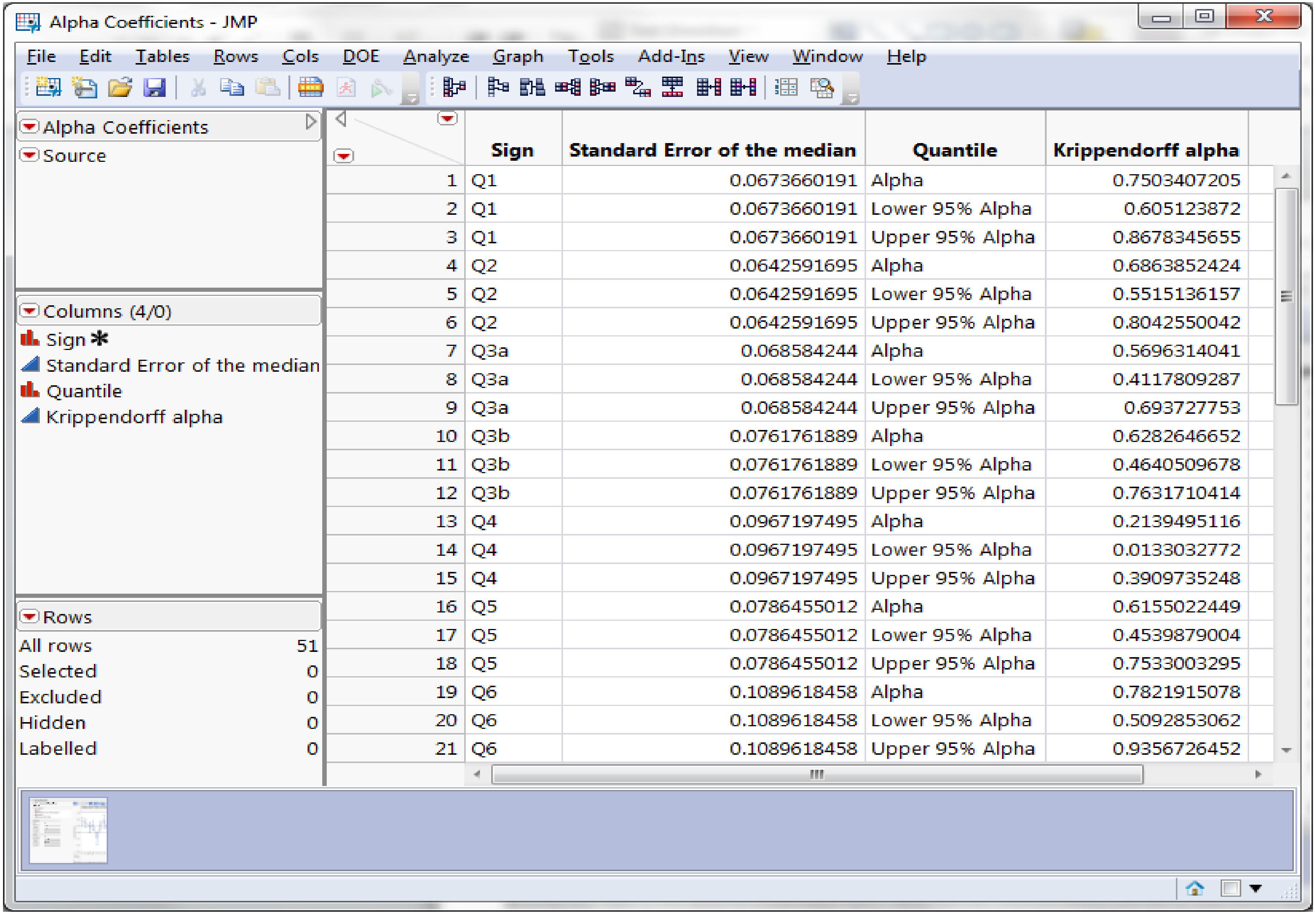
- Sign
- Alpha
- Standard Error of the median
- Lower 95% Alpha
- Upper 95% Alpha

Rows

All rows	17
Selected	0
Excluded	0
Hidden	0
Labelled	0

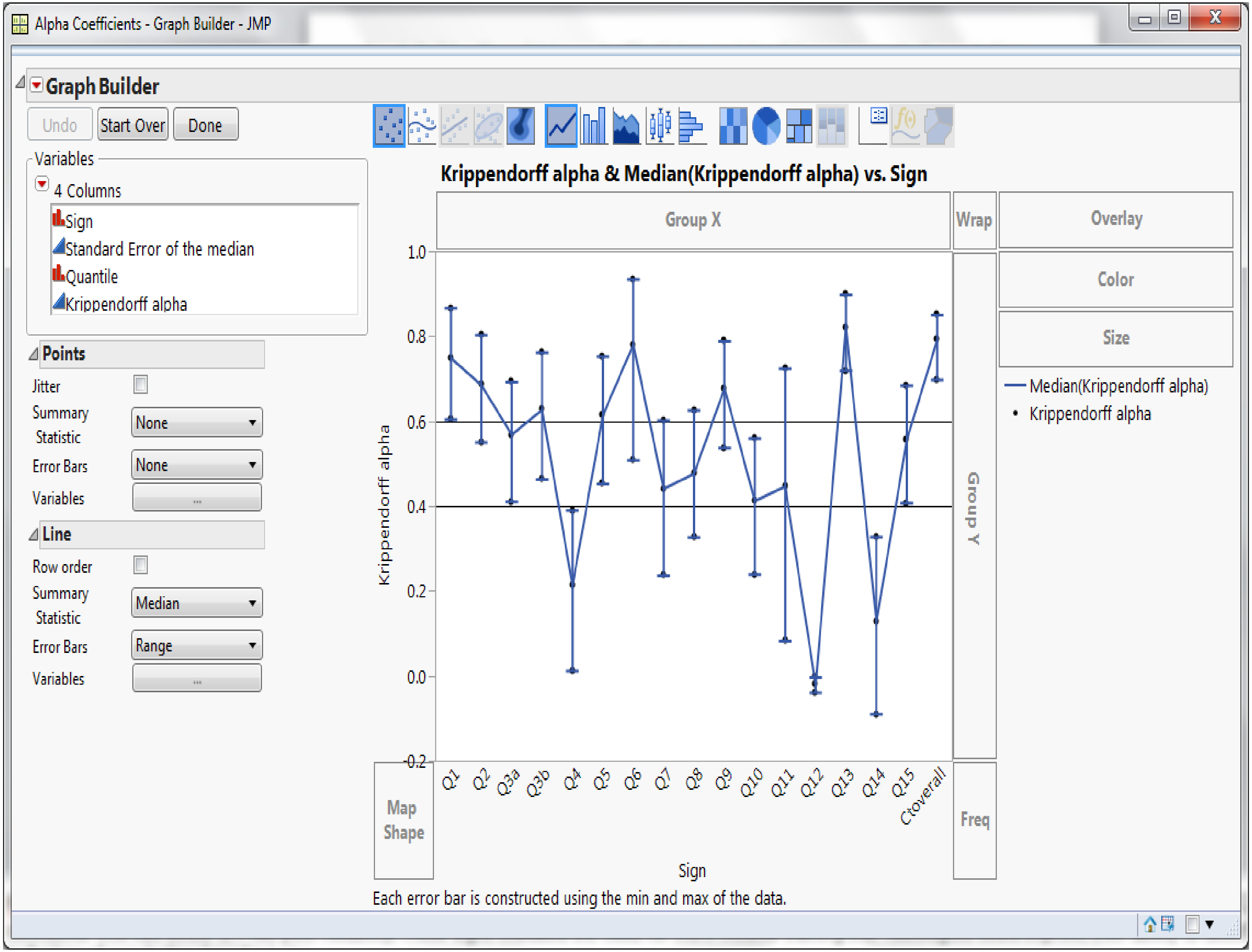
	Sign	Alpha	Standard Error of the median	Lower 95% Alpha	Upper 95% Alpha
1	Q1	0.7503407205	0.0673660191	0.605123872	0.8678345655
2	Q2	0.6863852424	0.0642591695	0.5515136157	0.8042550042
3	Q3a	0.5696314041	0.068584244	0.4117809287	0.693727753
4	Q3b	0.6282646652	0.0761761889	0.4640509678	0.7631710414
5	Q4	0.2139495116	0.0967197495	0.0133032772	0.3909735248
6	Q5	0.6155022449	0.0786455012	0.4539879004	0.7533003295
7	Q6	0.7821915078	0.1089618458	0.5092853062	0.9356726452
8	Q7	0.4424166103	0.0939232452	0.237861742	0.6028726855
9	Q8	0.4775304141	0.0769103174	0.3276420937	0.6268635406
10	Q9	0.6790435774	0.0637603594	0.5384322913	0.7895230257
11	Q10	0.4134978718	0.0818086061	0.2397866828	0.5604381094
12	Q11	0.4477476322	0.1623261924	0.0834909273	0.7251071094
13	Q12	-0.019908968	0.0650933494	-0.038277248	-0.002173913
14	Q13	0.8223807001	0.047156654	0.720483304	0.8992787812
15	Q14	0.1285898652	0.1073809241	-0.088778552	0.3285515847
16	Q15	0.5571417835	0.0715141086	0.4083534376	0.6852612036
17	Ctoverall	0.792743252	0.0391764202	0.6985028447	0.8509944042

Stacked Column of Krippendorff's Alphas (Coefficient and 95% Confidence Interval Values)



	Sign	Standard Error of the median	Quantile	Krippendorff alpha
1	Q1	0.0673660191	Alpha	0.7503407205
2	Q1	0.0673660191	Lower 95% Alpha	0.605123872
3	Q1	0.0673660191	Upper 95% Alpha	0.8678345655
4	Q2	0.0642591695	Alpha	0.6863852424
5	Q2	0.0642591695	Lower 95% Alpha	0.5515136157
6	Q2	0.0642591695	Upper 95% Alpha	0.8042550042
7	Q3a	0.068584244	Alpha	0.5696314041
8	Q3a	0.068584244	Lower 95% Alpha	0.4117809287
9	Q3a	0.068584244	Upper 95% Alpha	0.693727753
10	Q3b	0.0761761889	Alpha	0.6282646652
11	Q3b	0.0761761889	Lower 95% Alpha	0.4640509678
12	Q3b	0.0761761889	Upper 95% Alpha	0.7631710414
13	Q4	0.0967197495	Alpha	0.2139495116
14	Q4	0.0967197495	Lower 95% Alpha	0.0133032772
15	Q4	0.0967197495	Upper 95% Alpha	0.3909735248
16	Q5	0.0786455012	Alpha	0.6155022449
17	Q5	0.0786455012	Lower 95% Alpha	0.4539879004
18	Q5	0.0786455012	Upper 95% Alpha	0.7533003295
19	Q6	0.1089618458	Alpha	0.7821915078
20	Q6	0.1089618458	Lower 95% Alpha	0.5092853062
21	Q6	0.1089618458	Upper 95% Alpha	0.9356726452

Graph Builder Plot of Krippendorff's Alphas and Confidence Intervals for each Sign



Attribute Gauge Agreement Comparison Results of Three Readers for Signs Q1, Q6 and Q13

Agreement Comparisons for Sign Q1

Rater	Compared with Rater	Kappa	Standard Error
1	2	0.6119	0.0459
1	3	0.6996	0.0445
2	3	0.6329	0.0459

Rater	Compared with Standard	Kappa	Standard Error
1	Standard rating	1.0000	0.0000
2	Standard rating	0.6119	0.0459
3	Standard rating	0.6996	0.0445

Agreement within Raters

Agreement across Categories

Category	Kappa	Standard Error
1	0.7268	0.0442
2	0.0497	0.0442
3	0.0454	0.0442
4	0.0529	0.0442
5	0.8224	0.0442
Overall	0.6466	0.0336

Agreement Comparisons for Sign Q6

Rater	Compared with Rater	Kappa	Standard Error
1	2	0.8677	0.0469
1	3	0.9009	0.0426
2	3	0.8635	0.0483

Rater	Compared with Standard	Kappa	Standard Error
1	Standard rating	1.0000	0.0000
2	Standard rating	0.8677	0.0469
3	Standard rating	0.9009	0.0426

Agreement within Raters

Agreement across Categories

Category	Kappa	Standard Error
1	0.9048	0.0442
2	-0.008	0.0442
3	-0.006	0.0442
4	-0.002	0.0442
5	0.8014	0.0442
.	1.0000	0.0442
Overall	0.8771	0.0340

Agreement Comparisons for Sign Q13

Rater	Compared with Rater	Kappa	Standard Error
1	2	0.7195	0.0530
1	3	0.7637	0.0500
2	3	0.8044	0.0453

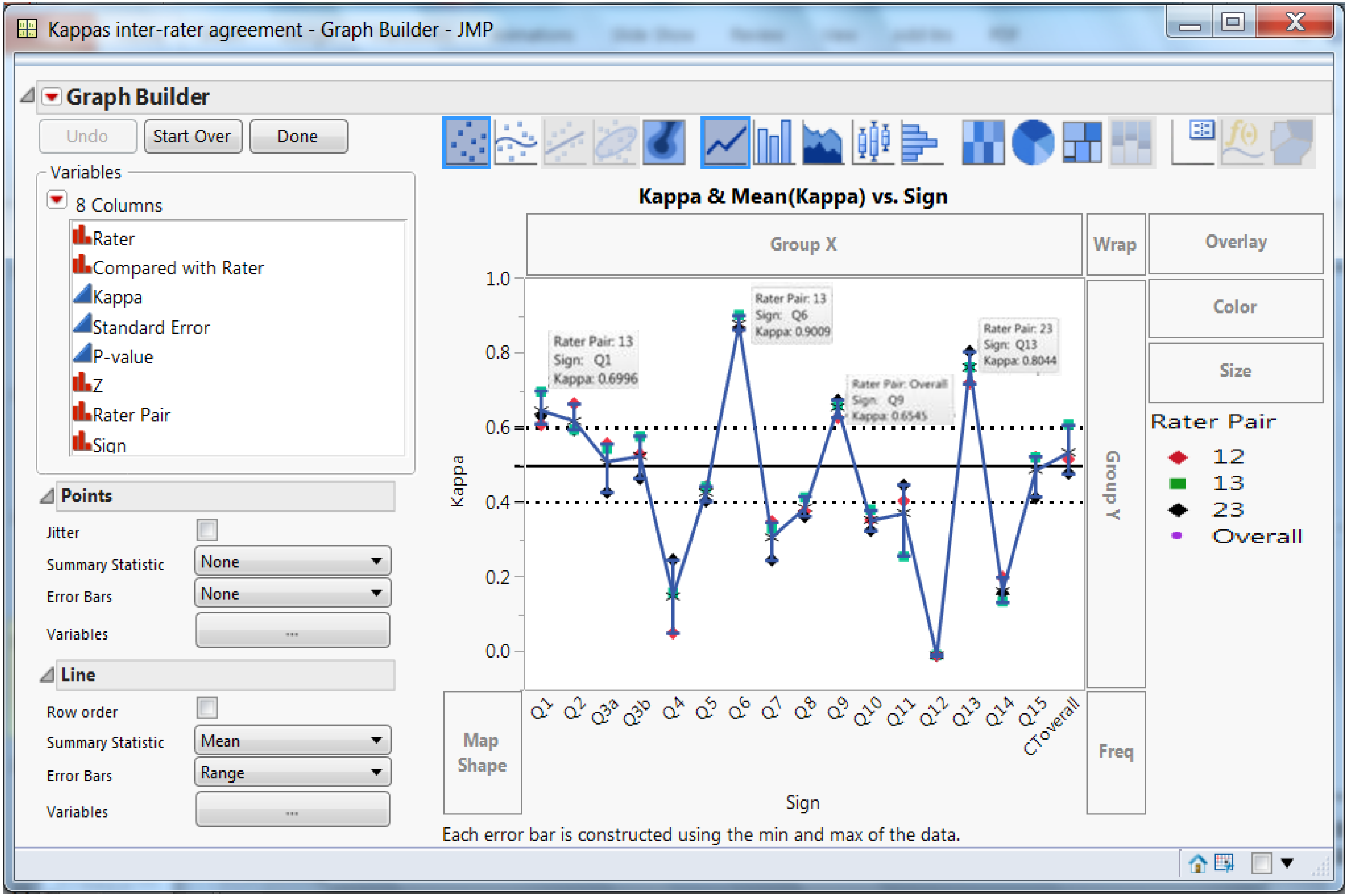
Rater	Compared with Standard	Kappa	Standard Error
1	Standard rating	1.0000	0.0000
2	Standard rating	0.7195	0.0530
3	Standard rating	0.7637	0.0500

Agreement within Raters

Agreement across Categories

Category	Kappa	Standard Error
1	0.8066	0.0442
2	0.3294	0.0442
3	0.0952	0.0442
4	-0.014	0.0442
5	0.8407	0.0442
Overall	0.7628	0.0389

Graph Builder Plot of Paired Raters and Overall Kappa Values for each Sign



Opened Fleiss Kappa and Krippendorff Alpha Data Tables with Script to Join them

Overall Kappas Subset inter-rater agreement - JMP

File Edit Tables Rows Cols DOE Analyze Graph Tools Add-Ins View Window Help

Overall Kappas Subset int...
Source
Graph Builder Box Plot
Graph Builder - Rater Pair P
Graph Builder with kappa re
Graph Builder with Rater pa
Graph Builder with Box Plot

Columns (8/0)
Rater
Compared with Rater
Kappa
Standard Error
P-value
Z

Rows
All rows 17
Selected 0
Excluded 0
Hidden 0
Labelled 0

		Compared with Rater	Kappa	Standard Error	P-value	Z	Rater Pair	Sign
*	1	Overall	0.6466	0.0336	0	19.219868	Overall	Q1
*	2	Overall	0.6189	0.0391	0	15.822098	Overall	Q2
*	3	Overall	0.5087	0.0379	0	13.411656	Overall	Q3a
*	4	Overall	0.5255	0.0359	0	14.651245	Overall	Q3b
*	5	Overall	0.1511	0.0299	2.1433942e-7	5.0557606	Overall	Q4
*	6	Overall	0.4304	0.0297	0	14.505393	Overall	Q5
*	7	Overall	0.8771	0.0340	0	25.762526	Overall	Q6
*	8	Overall	0.3078	0.0289	0	10.644993	Overall	Q7
*	9	Overall	0.3868	0.0315	0	12.274315	Overall	Q8
*	10	Overall	0.6545	0.0392	0	16.679304	Overall	Q9
*	11	Overall	0.3528	0.0320	0	11.009572	Overall	Q10
*	12	Overall	0.3753	0.0287	0	13.084	Overall	Q11
*	13	Overall	-0.0075	0.0353	0.5837848682	-0.211586	Overall	Q12
*	14	Overall	0.7628	0.0389	0	19.589224	Overall	Q13
*	15	Overall	0.1647	0.0311	5.6795891e-8	5.3035183	Overall	Q14
*	16	Overall	0.4877	0.0310	0	15.739838	Overall	Q15
*	17	Overall	0.5349	0.0262	0	20.381166	Overall	CToverall

evaluations done

Krippendorff Alpha and 95%CI - JMP

File Edit Tables Rows Cols DOE Analyze Graph Tools Add-Ins View Window Help

Krippendorff Alpha and 95%CI
Stack Alphas and 95% CIs and plc

Columns (5/0)
Sign
Alpha
Standard Error of the median
Lower 95% Alpha
Upper 95% Alpha

Rows
All rows 17
Selected 0
Excluded 0
Hidden 0
Labelled 0

	Sign	Alpha	Standard Error of the median	Lower 95% Alpha	Upper 95% Alpha
1	Q1	0.7503407205	0.0673660191	0.605123872	0.8678345655
2	Q2	0.6863852424	0.0642591695	0.5515136157	0.8042550042
3	Q3a	0.5696314041	0.068584244	0.4117809287	0.693727753
4	Q3b	0.6282646652	0.0761761889	0.4640509678	0.7631710414
5	Q4	0.2139495116	0.0967197495	0.0133032772	0.3909735248
6	Q5	0.6155022449	0.0786455012	0.4539879004	0.7533003295
7	Q6	0.7821915078	0.1089618458	0.5092853062	0.9356726452
8	Q7	0.4424166103	0.0939232452	0.237861742	0.6028726855
9	Q8	0.4775304141	0.0769103174	0.3276420937	0.6268635406
10	Q9	0.6790435774	0.0637603594	0.5384322913	0.7895230257
11	Q10	0.4134978718	0.0818086061	0.2397866828	0.5604381094
12	Q11	0.4477476322	0.1623261924	0.0834909273	0.7251071094
13	Q12	-0.019908968	0.0650933494	-0.038277248	-0.002173913
14	Q13	0.8223807001	0.047156654	0.720483304	0.8992787812
15	Q14	0.1285898652	0.1073809241	-0.088778552	0.3285515847
16	Q15	0.5571417835	0.0715141086	0.4083534376	0.6852612036
17	Ctoverall	0.792743252	0.0391764202	0.6985028447	0.8509944042

evaluations done

Script for Overall Kappas Subset inter-rater agreement - JMP

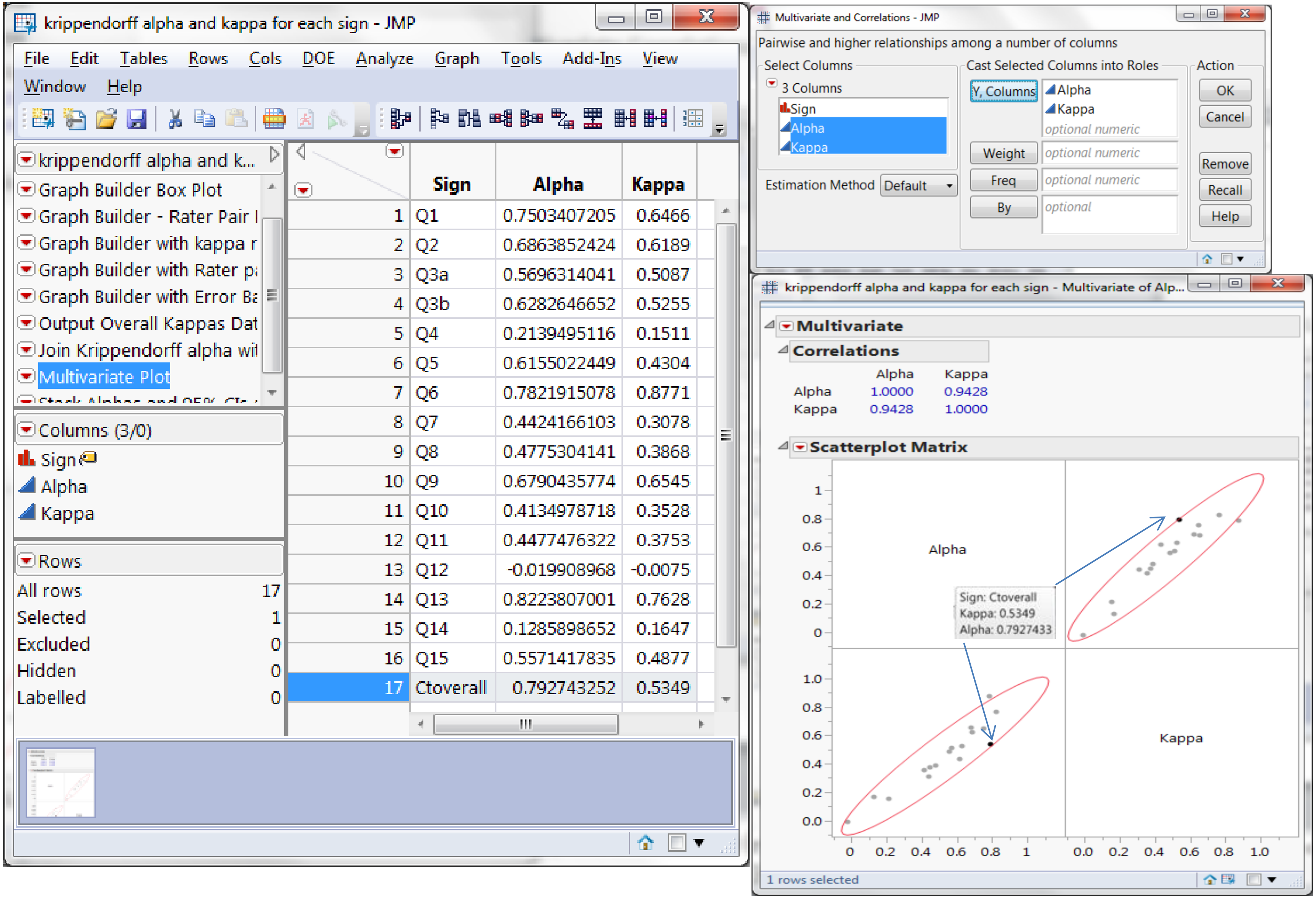
Name: Join Krippendorff alpha with kappas

Script:

```
Data Table( "Overall Kappas Subset inter-rater agreement" ) <<
Join(
    With( Data Table( "Krippendorff Alpha and 95%CI" ) ),
    SelectWith( :Sign, :Alpha ),
    Select( :Kappa ),
    By Row Number,
    Output Table( "krippendorff alpha and kappa for each sign" )
)
```

OK | Run | Debug Script | Save | Cancel

Multivariate Correlations between the Krippendorff alpha and overall Fleiss' Kappa statistics



	Sign	Alpha	Kappa
1	Q1	0.7503407205	0.6466
2	Q2	0.6863852424	0.6189
3	Q3a	0.5696314041	0.5087
4	Q3b	0.6282646652	0.5255
5	Q4	0.2139495116	0.1511
6	Q5	0.6155022449	0.4304
7	Q6	0.7821915078	0.8771
8	Q7	0.4424166103	0.3078
9	Q8	0.4775304141	0.3868
10	Q9	0.6790435774	0.6545
11	Q10	0.4134978718	0.3528
12	Q11	0.4477476322	0.3753
13	Q12	-0.019908968	-0.0075
14	Q13	0.8223807001	0.7628
15	Q14	0.1285898652	0.1647
16	Q15	0.5571417835	0.4877
17	Ctoverall	0.792743252	0.5349

	Alpha	Kappa
Alpha	1.0000	0.9428
Kappa	0.9428	1.0000

Summary and Conclusions

- In closing, we saw how JMP‘s JSL with R integration computed Krippendorff’s alpha inter-rater reliability statistic, that surpasses Fleiss’ kappa in JMP.
- Although Krippendorff alpha is not as widely used and is more computationally complex than Fleiss’ kappa, it has gained more acceptance by researchers in content analysis and measurement reproducibility studies as a robust, flexible, inter-coder reliability metric.
- Combining JMP‘s dynamic interactivity with R’s unique functionalities and packages gives users the ability to develop custom applications that can be implemented in JMP.

Acknowledgements

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