

Visual Hypothesis Testing with Confidence Intervals

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ABSTRACT

A simple visual method of comparing means given normal 95% confidence intervals is proposed. Monte Carlo simulations were used to derive a visual rule of thumb that can be used to test the null hypothesis of equal means, given the confidence intervals of the means, and the sample sizes (or degrees of freedom). The type-1 error rate of the test is approximately .05. The rule involves accepting the null hypothesis when a confidence interval for either mean overlaps the other mean, and rejecting the null hypothesis otherwise. In some cases with moderate to high sample sizes and/or similar-sized confidence intervals, the original confidence intervals need to be extended before the null hypothesis can be rejected by the rule. The rule is most easily applied when the means and confidence intervals are displayed with auxiliary information that includes the degrees of freedom and potential extensions to the confidence interval bounds. To display results in this manner, a SAS macro utilizing the annotate facility with the SAS Gplot procedure is provided.

INTRODUCTION

The relationship between a confidence interval and a hypothesis test is that the confidence interval contains all the values of the population mean that could serve as the null hypothesis value (for equality of means) and the null hypothesis would not be rejected at the nominal type-1 error rate (Nelson 1990). Rather than rely solely on p values from statistical tests, there are practical advantages of using confidence intervals for hypothesis testing (Wonnacott 1987, Nelson 1990). For most people, confidence intervals are easier to understand. Confidence intervals also provide additional useful information since they include a point estimate of the mean, and the width of the interval gives an idea of the precision of the mean estimation.

The most direct manner of comparing pairs of means with confidence intervals is to compute confidence interval for the *difference* between each pair of estimated means. If the confidence interval covers a value of zero, then the null hypothesis is accepted at the type-1 error rate of $100-p$ (Gardner and Altman 1989, Hsu and Peruggia 1994, Lo 1994), where p is the percent coverage of the confidence intervals. With this approach the visual advantage of the confidence interval of the mean is lost. The individual means and their uncertainty will be obscured. Also, if several estimated means are to be compared, there will be $n(n-1)/2$ separate confidence intervals of the differences to display (n =the number of means compared). This can be a very large number of confidence intervals.

Another common approach is to reject the null hypothesis when the 95% confidence intervals of the means do not overlap. Barr (1969), Nelson (1989), and Lo (1994) show that using the overlap criterion with 95% confidence intervals of the mean will be associated with an actual type-1 error rate as low as .005 and relatively low power. Thus this approach represents a relatively insensitive test.

Most other graphical techniques for comparing means with statistical intervals involve intervals that are specialized for hypothesis testing. For example, with *uncertainty or comparison intervals* (Gabriel 1978, Andrews et al. 1980, Hochbert et al. 1982, Hochbert and Tamhane 1987, Lenth 1988, Hsu and Peruggia 1994, Goldstein

and Healy 1995), the interval bounds are computed so that the null hypothesis of equal means is rejected (at a nominal type-1 comparisonwise or experimentwise error rate) when the uncertainty intervals of a pair of means do not overlap. The uncertainty interval methods can be exact when the samples sizes are balanced and standard errors for the means are homogeneous. Otherwise, the interval sizes will usually be rough approximations since different sized intervals would be required for comparisons of different pairs of means (when more than two means are to be compared). Hsu and Peruggia (1994) discuss approximation methods for unbalanced designs, and Hochberg (1976) and Lenth (1988) give approximations for unequal standard errors of the means.

My objectives in developing the technique presented in this paper were to provide a method where

1. hypothesis tests on the equality of means could rapidly be made with a simple rule of thumb and without computations,
2. the comparisonwise type-1 error of the tests will approximate a known nominal type-1 error rate whether the design is balanced or unbalanced and whether the standard errors of the means are homogeneous or heterogeneous, and
3. a commonly displayed statistical interval is used directly in the hypothesis test. The 95% (or 90%) confidence interval of the mean was chosen for this purpose. This objective precluded using uncertainty interval methods.

Browne (1979) provides an approach for using 95% confidence intervals of the mean to test for the equality of means at a nominal .05 type-1 error level. The method is based on a D statistic, which for each pair of means is the ratio of the difference in the two upper confidence bounds to the length of the smaller of the two confidence intervals. A table is provided with D values for several sets of sample sizes and different M ratios. An M ratio is the ratio of the larger interval to the smaller interval for a pair of means being compared. The D values in the table are minimum D values for which the means will be significantly different. From the patterns of the D values in the table, the author provided a few rules of thumb that covered some but not all situations. The D values in Browne's table (Browne 1979) were directly computed using the definition of the t statistic for the difference in two means. I use a simulation approach in an attempt to obtain a more general and simpler rule of thumb.

In this paper, I describe a visual test using confidence intervals to test the null hypothesis of equal means with known approximate nominal type-1 error rates. The test is visual in that it requires no statistical computations, and can be directly applied to results presenting confidence intervals. Only the degrees of freedom and the approximate ratio of the lengths of the respective confidence intervals are needed. I propose a simple rule of thumb to accomplish this for confidence intervals based on normal distributions. My main focus is on two-tailed tests with a nominal type-1 error rate of .05 ($\alpha = .05$). I present an example plot that includes useful auxiliary information for easily applying the proposed method, along with a SAS macro that can be used to produce similar plots.

METHODS

Rule of thumb for hypothesis testing

As a starting point for developing a rule of thumb for hypothesis testing with confidence intervals, I propose the following rule of thumb with two-tailed 95% confidence intervals.

Rule of thumb: *Accept the null hypothesis of equal means for two estimated means if either mean is within the 95% confidence interval of the other mean. Otherwise, reject the null hypothesis.*

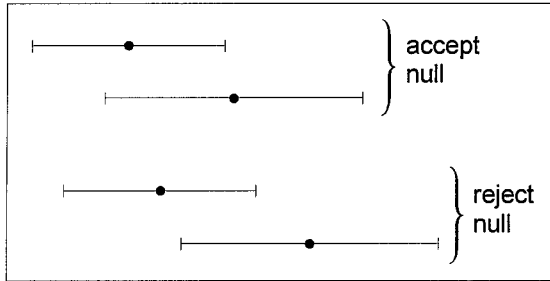


Figure 1. Rule of thumb. The null hypothesis is accepted if either confidence interval includes the mean of the other.

The rule is illustrated in Figure 1. To test type-1 error levels associated with this rule, I performed Monte Carlo simulations for two normal populations with equal means. Many simulation scenarios with different sample sizes and population variances were used to approximate a wide variety of situations. Simulations were performed in SAS. Each simulation scenario involved randomly drawing 100,000 samples from each of the two normal populations, using the RANNOR function. For each sample, the population sample mean and confidence limits were computed. The upper (U) and lower (L) bounds of two-tailed confidence limits were computed as

$$L = \bar{x} - t_{.975,df} s / \sqrt{n} \quad (1)$$

and

$$U = \bar{x} + t_{.975,df} s / \sqrt{n}, \quad (2)$$

where \bar{x} , s , and df are the estimated mean, standard deviation, and degrees of freedom, respectively, for a sampled population. In the simulations, $df=n-1$, where n is the sample size. The $t_{.975,df}$ is the value for the 97.5th percentile of the cumulative t distribution with df degrees of freedom.

Preliminary simulations showed that the actual type-1 error rates varied with the degrees of freedom and the ratio of the lengths of the confidence intervals being compared. The ratio of confidence intervals lengths (R) for a simulation scenario is computed as

$$R = \frac{\text{Max}(\bar{L}_1, \bar{L}_2)}{\text{Min}(\bar{L}_1, \bar{L}_2)}, \quad (3)$$

where \bar{L}_1 and \bar{L}_2 are the average estimated lengths of the confidence intervals for the two populations over all simulations. R is simply the ratio of the expected value of the larger confidence interval to the expected value of the smaller confidence interval. Variation in R is produced by using different population variances and sample sizes in the different simulation scenarios.

Figure 2 summarizes the pattern of actual type-1 error rates, which are the proportion of the simulations (within a scenario) for which the null hypothesis of equal means is rejected using the rule of thumb. Separate plots are shown for different ranges of R that produced similar results. In these, the simulation type-1 error rates are shown as a function of the degrees of freedom for the two population samples. Lines are drawn to delimit blocks of

sample-size combinations where the actual type-1 error levels are roughly similar. Type-1 error rates within the block labeled " $A=0$ " are close to .05 or, in a few cases involving minimal degrees of freedom, the rates get low as .01. Most of the type-1 error rates in the block labeled " $A=.3$ " are over twice the .05 rate, and the type-1 error rates in the blocks labeled " $A=.1$ " or " $A=.2$ " are moderately above the .05 rate. The results in Figure 2 indicate that in most cases where the R is relatively high (Figure 2c) or the sample size of at least one of the populations is relatively low (Figures 2a and 2b), the rule generally works well if one is interested in a nominal type-1 error rate of .05.

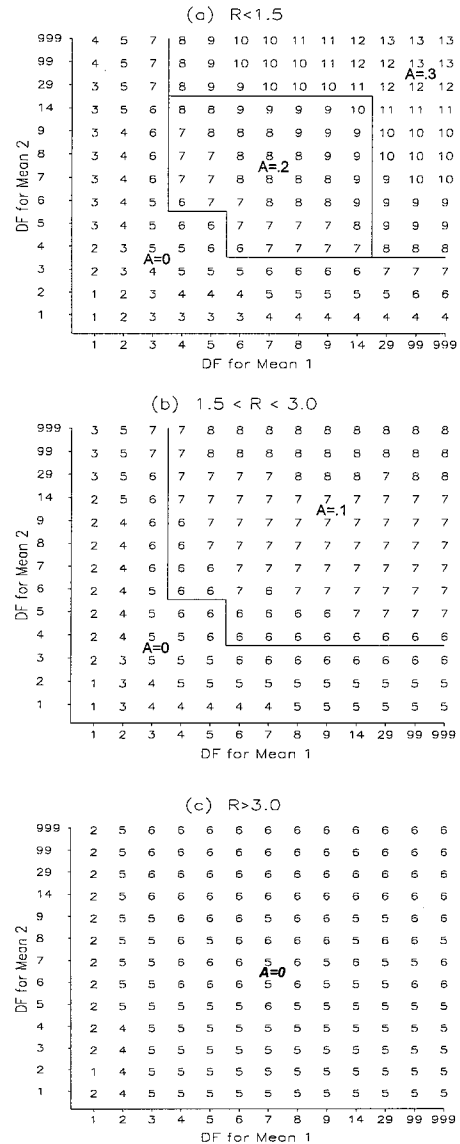


Figure 2. Actual simulation type-1 error rates using rule of thumb for multiple simulation scenarios involving different degrees of freedom and R ratios. The two-tailed error rates are shown as 100(error rate), rounded to the nearest digit. For example, an error rate of .051 would appear as a "5", and an error rate of .066 would appear as a "7". The rates are blocked into regions with generally similar error rates. The indicated values for A are used to modify the confidence intervals to improve the type-1 error rate. Where $R>1$, the expected confidence interval length for mean 1 is greater than the expected confidence interval length for mean 2. For (a) $R \leq 1.5$, (b) $R = 1.5$ to 3, and (c) $R > 3$.

Application of the rule of thumb to extended confidence intervals. The more common situation where rule of thumb fails involves lower R values and/or higher degrees of freedom ($A > 0$ in Figure 2). To correct for this, I propose extending the interval bounds to produce type-1 error rates closer to .05 in cases where the initial type-1 error rates are too high. The rule of thumb is then applied to the extended confidence bounds. For a pair of means being compared, the rules for interval modification are as follows.

1. Make no modifications to the interval bounds if the null hypothesis has been accepted by the rule, since extension of the bounds cannot cause rejection of the null hypothesis.
2. Make no modifications if the confidence intervals for the two means do not overlap. As noted in the introduction, a test using interval overlap will generally be associated with very low type-1 error, so we will not reverse the decision to reject the null hypothesis in cases of non-overlap.
3. Make no modifications for situations corresponding to areas labeled "A=0" in Figure 2. The type-1 error in these areas are already for the most part satisfactory.
4. Make no modifications if it appears that as much as a 30% extension of the half intervals will not change the decision on rejection of the null hypothesis. As shown below, the maximum proposed extension of the half intervals is 30% ($A=.3$), so if this amount of extension will not change our decision, there is no need to go through the process of determining the best modification for the specific situation.
5. If rule 4 above is not applied, make modifications for situations corresponding to areas labeled "A=.1", "A=.2" or "A=.3" in Figure 2.

The modification of the confidence intervals, which involves a visual extension of the interval lengths for the means being compared is now described. The confidence interval length ratio for a pair of samples is

$$R_{est} = \frac{Max(\widehat{L}_1, \widehat{L}_2)}{Min(\widehat{L}_1, \widehat{L}_2)} \quad (4)$$

where \widehat{L}_1 and \widehat{L}_2 are the estimated confidence interval lengths for the first and second samples, respectively. The R_{est} value for a pair of means is needed to determine the value of the adjustment factor A (see below).

A separate potential modification is required for each pair of means to be compared. The modified upper and lower confidence interval bounds for each mean being compared are

$$U_{mod} = U + A(U - \bar{x}), \quad (5)$$

and

$$L_{mod} = L - A(\bar{x} - L), \quad (6)$$

where L , U , and \bar{x} are defined in (1) and (2). The value for A is taken from Figure 2, and depends on the R_{est} and the degrees of freedom associated with the two estimated means. If $R_{est} \leq 1.5$ use Figure 2a, or if $1.5 < R_{est} < 3.0$ use Figure 2b. When $R_{est} > 3$, no adjustment is needed since $A=0$ for all degrees of freedom (see Figure 2c). Note that the adjustment factor A is applied to one half the length of the confidence intervals ($\bar{x} - L$ or $U - \bar{x}$) rather than to the full length of the confidence intervals ($U-L$). I could just as easily halved the size of the A values and used the entire confidence interval length. However I chose to work with the half size interval because it is easier to visually apply the modification to the shorter length of the half interval.

Figure 3 shows the type-1 error rates when the rule of thumb is applied with extended intervals where necessary. The simulation type-1 error rates are now closer to .05. The error rates when the larger confidence interval (for mean 1) is associated with 1 degree of freedom are still low. To keep things simple, I made no attempt to correct for this situation since it would entail reducing the interval sizes. It is probably not a bad idea to accept a con-

servative test when the degrees of freedom are so minimal for one of the means.

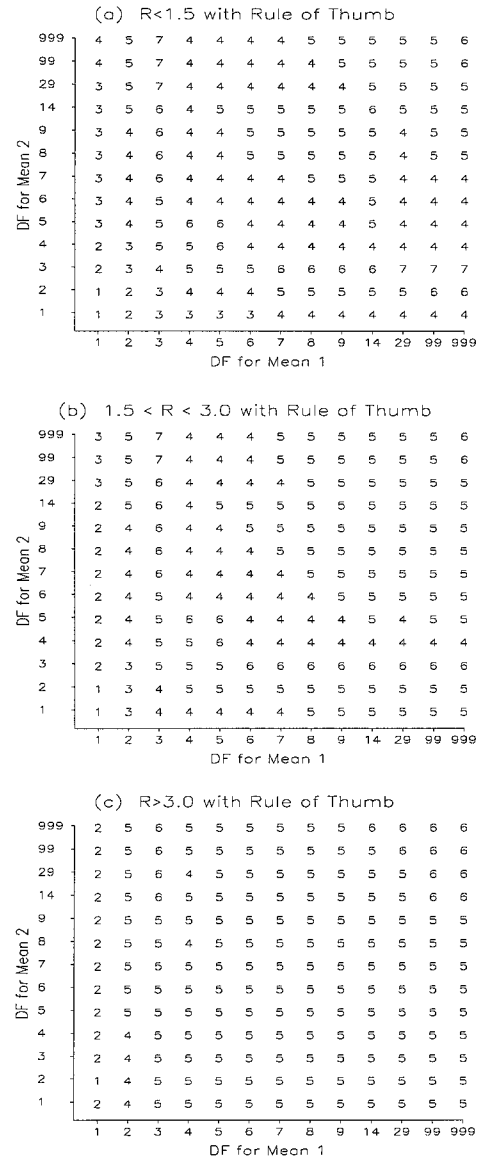


Figure 3. Simulation type-1 error rates using rule of thumb for simulation scenarios with (a) $R \leq 1.5$, (b) $R = 1.5$ to 3, and (c) $R > 3$. See Figure 2 for explanation of values in plots.

The confidence interval modification is illustrated with an example. The confidence interval for one sample mean is 11 ± 5 , the confidence interval for a second mean is 17 ± 2 , and the respective degrees of freedom are 7 and 39. Using (4), (5), and (6), the modified lower confidence interval bound for the first mean is $L_{mod} = 6 - .1(11-6) = 5.5$, and $U_{mod} = 16 + .1(16-11) = 16.5$. Here $A = .1$, since $R_{est} = 10/4 = 2.5$ and thus A is taken from Figure 2b for degrees of freedom of 7 and 39. For mean 2, $L_{mod} = 15 - .1(17-15) = 14.8$, and $U_{mod} = 19 + .1(19-17) = 19.2$.

Given the rules for modification above and the patterns in Figure 2, a summary of the rule of thumb as modified to apply to the extended intervals is given in Figure 4. In practice, the application of the rule of thumb need not be too complicated nor require repeated reference to Figure 2. In most cases, it should be easy to visually determine the approximate value for R_{est} , and with some experience, extensions of the intervals corresponding to the different values of A should become simple. When the data

are displayed as in the example shown below (Figure 5), the application of the rule should be even more simplified.

Incidentally, a one-tailed comparison of means with approximately a .05 type-1 error rate can be obtained with the exactly the same rule of thumb by using 90% instead of 95% confidence intervals.

Use the rule of thumb directly if:

- no overlap of confidence intervals, or
- null hypothesis accepted with rule of thumb, or
- high R_{est} ($R_{est} > 3$), or
- low degrees of freedom ($Max(df) < 6$ or $Min(df) < 4$)

Otherwise extend the intervals as follows before applying the rule of thumb:

- If $R_{est} > 1.5$ let $A=.1$,
- otherwise
- if $Max(df) < 14$, let $A=.2$
- otherwise let $A=.3$.

Figure 4. Rule of thumb extended to apply to modified intervals if necessary. $Max(df)$ is the maximum degrees of freedom for the two sample means being compared, and $Min(df)$ is the minimum degrees of freedom for the two means being compared.

RESULTS

Example

Figure 5 shows a hypothetical example plot showing some estimated means and confidence intervals. To aid in applying the proposed rule of thumb, I have included the associated degrees of freedom ($df=$) and three dots corresponding to interval adjustments for $A=.1$, $A=.2$, and $A=.3$ (in case modified intervals are needed). Table 1 summarizes the rules applied and acceptance or rejection of the null hypothesis for each pair of treatments.

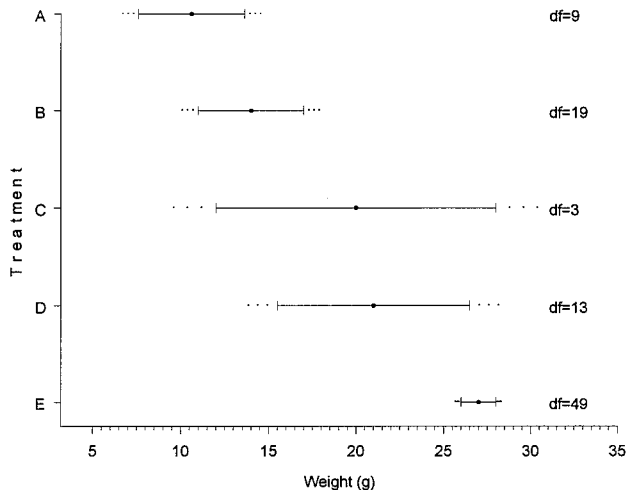


Figure 5. Hypothetical example for body weights of test organisms exposed to five different treatments (A-E). The five treatment sample means and their estimated confidence intervals, along with the associated degrees of freedom ($df=$) are shown. The three dots outside the interval bounds correspond to modifications of the interval bounds corresponding to $A=.1$, $A=.2$, and $A=.3$, respectively.

Table 1. Results of hypothesis tests for all pairs of means in Figure 5 using the rule of thumb. An "M" in the lower diagonal indicates that modified intervals were used in the decision. In the upper diagonal, "A" indicates acceptance and "R" indicates rejection of the null hypothesis for the treatment pair using the rule of thumb.

		TREATMENT				
		A	B	C	D	E
TREATMENT	A	-	A	R	R	R
	B	M	-	A	R	R
	C			-	A	A
	D				M	-
	E					M

Given the display in Figure 5 with the degrees of freedom and the dots for potential adjustments, it is a simple matter to determine which comparisons will require using an adjusted interval. For the example data, only the A-B and B-D comparisons require modified intervals before application of rule of thumb. All other comparisons are directly handled by the rule because they meet at least one of the criteria at the top of Figure 4.

Macro B PLOT

The SAS macro B PLOT, which produces output similar to that shown in Figure 5, is presented in Appendix A. Macro B PLOT uses the G PLOT procedure and the Annotate facility of SAS/GRAPH®.

CONCLUSION

A simple visual rule of thumb is presented for comparing means using 95% confidence intervals. For the most part, the method controls the type-1 error for a 2-tailed test of the null hypothesis of equal means at approximately .05. A SAS macro is included for presenting means and confidence intervals in a manner that facilitates applying the rule of thumb.

ACKNOWLEDGMENTS

Dr. Allan Stewart-Oaten provided some comments that were very useful in refining my approach.

TRADEMARKS

SAS/GRAPH is a registered trademark of SAS Institute Inc. in the USA and other countries. ® indicates USA registration.

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```
device=LJIVPS, /* Device parm for GOPTIONS
               statement*/
tardev=LJIVPS, /* targetdevice parm for GOPTIONS
               statement */
gaccess=,     /* gaccess parm for GOPTIONS
               statement */
goutmode=,    /* goutmode parm for GOPTIONS
               statement */
bfont=SWISS,  /* Name of font for vertical bars at
               ci bounds
               Note: SIMPLEX works best with cgm
               device file to be imported into
               WORD */
titlfont=SWISSB, /* Font for plot main title */
texfont=SWISS; /* Font for text in plot */
```

```
%local nprop ngapp dflab setgopt ndot word srtv nform
mxlen i ndot dot1
      dot2 dot3 maxx minx
      c1 c2 c3 c4 c5 c6 c7 c8 c9 c10 c11 c12 c13 c14 c15
c16 c17 c18 c19 c20
      f1 f2 f3 f4 f5 f6 f7 f8 f9 f10 f11 f12 f13 f14 f15
f16 f17 f18 f19 f20;
```

```
/*---- SOME DEFAULTS;
%let nprop=.10;%let ngapp=.03;%let dflab=%quote(df=);
%let title=%quote(&title);
/*---- PARSE DOT PROPORTIONS;
%let ndot=0;
%do %until(%word= );
  %let word=%qscan(&dotprope,%eval(&ndot+1),%str( ));
  %if %word ne %then %do;%let ndot=%eval(&ndot+1);%let
dot&ndot=%word;%end;
%end;
```

```
/*---- GOPTIONS STATEMENT;
%if %upcase(&setgopt)=Y %then
%do;
GOPTIONS RESET=ALL HSIZE=&hsize &units VSIZE=&vsize
&units
%if %device ne %then %do; DEVICE=&device %end;
%if %tardev ne %then %do; TARGETDEVICE=&tardev %end;
%if %goutmode ne %then %do; GOUTMODE=&goutmode %end;
%if %gaccess ne %then %do; GACCESS="&gaccess" %end;
;RUN;
%end;
```

```
/*---- SET UP DATA FOR Y AXIS ORDER;
%if %yorder ne %then
%let srtv=%yorder; %else %let srtv=%xmean;
```

```
PROC SORT DATA=&dsn OUT=SS_ BY DESCENDING &srtv;

DATA SSS_(KEEP=&yvar &xmean &xlci &xuci &df _YCD);
LENGTH _YCD $ 4 _IV $ 4 _YFORM $ 16;
RETAIN _I _MAXLEN 0;
SET SS_(KEEP=&yvar &xmean &xlci &xuci &df) END=EOF;
IF &xmean=. THEN DELETE;
ELSE
DO;
  _I=_I+1;
  _YCD=PUT(_I,Z4.);
  IF &xlci=. THEN &xlci=&xmean;
  IF &xuci=. THEN &xuci=&xmean;
  %if %yformat= %then %do; _YFORM=&yvar; %end;
  %else %do; _YFORM=PUT(&yvar,&yformat); %end;
  _MAXLEN=MAX(_MAXLEN,LENGTH(_YFORM));
  _IV=LEFT(PUT(_I,4.));
  CALL SYMPUT('c' || _IV,_YCD);
  CALL SYMPUT('f' || _IV,_YFORM);
END;
IF EOF THEN
DO;
  CALL SYMPUT('nform',LEFT(PUT(_I,4.)));
  CALL SYMPUT('mxlen',LEFT(PUT(_MAXLEN,2.)));
END;
RUN;

PROC FORMAT;
VALUE $YFORM
%do i=1 %to &nform;
```

APPENDIX A. THE B PLOT MACRO.

```
%macro bplot(
dsn=, /* Name of sas dataset with plot data */
yvar=, /* Name of variable with y data values (A
        separate mean with confidence
        intervals plotted for each value of
        the yvar= variable */
yformat=, /* Format for y variable (yvar=) */
yorder=, /* If yorder= (blank) the order on the Y
          axis will be in ascending order (top
          to bottom) of the xmean= variable.
          If yorder=variable name(s), then the
          order on the Y axis will be in
          ascending order of the values of the
          yorder= variable(s) */
xmean=, /* Name of variable with x mean values */
xlci=, /* Name of variable with x lower
        confidence limit */
xuci=, /* Name of variable with x upper
        confidence limit */
hsize=7, /* Horizontal size of plot area */
vsize=10, /* Vertical size of plot area */
units=in, /* Units for hsize and vsize */
xtick=, /* Set xtick= tick values for x axis */
df=, /* Name of variable with degrees of
      freedom to be plotted */
dfsize=.6, /* Size of df text */
dotprope=.1 .2 .3, /* Proportion expansions for each
                    half ci */
dotsize=.6, /* Size of the ci expansion dot(s) */
dotsize=.6, /* Size of the mean dot */
cisize=1, /* Size of vertical part of the
           confidence interval bars */
lnsize=1, /* Size of horizontal line for confidence
           interval bars */
title=, /* Main title for plot */
titlsiz=1, /* Size for title text */
xtitle=, /* X-axis title */
xtitlsiz=1, /* Set xtitlsiz = size for x axis title*/
ytitle=, /* Y-axis title */
ytitlsiz=1, /* Set ytitlsiz = size for y axis title*/
rotytitl=Y, /* Set rotytitl=Y to rotate the y title
             90 degrees */
setgopt=Y, /* If setgopt=Y, GOPTIONS statement
            used */
```

```

    %if %length(&&f&i)>&mxlen %then %do;
    "&&c&i"="%substr(&&f&i,1,&mxlen)" %end;
    %else %do; "&&c&i"="%&f&i" %end;
    %end; ;

DATA PLOTDS_;
SET SSS_;
FORMAT _YCD YFORM.;
RENAME &xuci=_XUCI &xlci=_XLCI &xmean=_XMEAN;

%*--- ANNOTATE DATA SET WITH LINES, N, AND DOTS;
%if &df&dotprope ne %then
%do;
DATA NPOS_(KEEP=_MAXX _MINX _MAXXF);
RETAIN _MAXX _MAXXF -999999 _MINX 999999;
SET PLOTDS _END=_EOF;
%if &ndot>0 %then
%do;
_X=_XUCI+(_XUCI-_XMEAN)*&&dot&ndot;
_XMIN=_XLCI-(_XMEAN-_XLCI)*&&dot&ndot;
%end;
%else %do; _X=_XUCI; _XMIN=_XLCI; %end;
_MAXX=MAX(_MAXX,_X);
_MINX=MIN(_MINX,_XMIN);
IF _EOF THEN
DO;
%if &df ne %then %do;
_MAXXF=_MAXX+(&nprop+&ngapp)*(_MAXX-_MINX); %end;
%else %do; _MAXXF=_MAXX; %end;
OUTPUT;
CALL SYMPUT('maxx',LEFT(PUT(_MAXX,BEST15.)));
CALL SYMPUT('minx',LEFT(PUT(_MINX,BEST15.)));
STOP;
END;
RUN;
%end;

DATA ANNO_;
LENGTH FUNCTION $5 POSITION $ 1 TEXT $ 16 STYLE $ 8;
RETAIN XSYS YSYS '2';
SET PLOTDS _END=_EOF;
FUNCTION='MOVE'; *-- move to beginning of CI;
YC=_YCD; X=_XLCI; OUTPUT; *-- draw horizontal line;
FUNCTION='DRAW'; SIZE=&lsize; YC=_YCD; X=_XUCI;
OUTPUT;
%*-- dots;
%if &dotprope ne %then
%do;
POSITION='B';SIZE=&dotsizee;TEXT='.';YC=_YCD;
%do i=1 %to &ndot;
FUNCTION='MOVE'; X=_XUCI+(_XUCI-_XMEAN)*&&dot&i;
OUTPUT;FUNCTION='LABEL';OUTPUT;
X=_XLCI-(_XMEAN-_XLCI)*&&dot&i; FUNCTION='MOVE';
OUTPUT; FUNCTION='LABEL'; OUTPUT;
%end;
%end;
%*-- df values;
%if &df ne %then
%do;
POSITION='6';STYLE="&texfont";SIZE=&dfsize;
%if &dflab ne %then %do;TEXT="&dflab" ||
LEFT(PUT(&df,6.));%end;
%else %do;TEXT=LEFT(PUT(&df,6.));%end;
YC=_YCD; _XADD=&ngapp*(&maxx-
&minx);FUNCTION='MOVE';X=&maxx+_XADD;OUTPUT;
FUNCTION='LABEL';OUTPUT;
%end;

```

```

%*--- ADD MIN AND MAX POSITIONS TO PLOT DATA;
DATA PLOTDS1_;
%if &df&dotprope ne %then %do; MERGE PLOTDS _NPOS_;
%end;
%else %do; SET PLOTDS1_; %end;
IF _XLCI=_XUCI THEN DO;_XLCI=.;_XUCI=.;END;

%*--- PLOTTING;
SYMBOL1 VALUE=dot HEIGHT=&dotsizee COLOR=BLACK;
SYMBOL2 VALUE='1' FONT=&bfont HEIGHT=&csize
COLOR=BLACK;
SYMBOL3 VALUE=dot HEIGHT=.00001 COLOR=WHITE;
AXIS1 LABEL= (F=&titlfont HEIGHT=&xtitlsiz "&xtitle")
OFFSET= (5 PCT,0 PCT) VALUE= (FONT=&texfont)
%if &xtick ne %then %do; ORDER=(&xtick) %end; ;
AXIS2 LABEL= (F=&titlfont HEIGHT=&ytitlsiz
%if &rotytitl=Y %then %do; ANGLE=90 %end;
"&ytitle")
OFFSET= (5 PCT, 0 PCT) VALUE= (FONT=&texfont);

PROC GPLOT DATA=PLOTDS1_;
PLOT _YCD*_XMEAN=1 _YCD*_XLCI=2 _YCD*_XUCI=2
%if &df&dotprope ne %then %do;_YCD*_MINX=3
_YCD*_MAXXF=3 %end;
/ OVERLAY HAXIS=AXIS1 VAXIS=AXIS2
ANNOTATE=ANNO_;
%if &title ne %then %do;TITLE FONT=&titlfont
HEIGHT=&titlsiz "&title";%end;
RUN; QUIT; RUN;
%mend bplot;

```

Contacting the Author

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