Paper SD - 06

A SAS Macro to Compute Effect Size (Cohen's d) and its Confidence Interval from Raw Survey Data

Rajendra P . Kadel, University of South Florida, Tampa, FL

Kevin E. Kip, University of South Florida, Tampa, FL

ABSTRACT

Effect size estimates are used to measure, in a standardized manner, the magnitude of treatment effect or association between two or more variables. The standardized mean difference (Cohen's d-statistic) between two or more conditions is a frequently used measure of effect size in both the social and biomedical sciences. In this situation, the response (dependent) variable is continuous, whereas the predictor (independent) variable is categorical. Although some web-based and Microsoft EXCEL-based software are available to calculate effect size using summary statistics, available software to calculate both effect size and corresponding confidence interval are limited. Moreover, to the authors' knowledge, there is no standard SAS® procedure that directly produces the d-statistic and confidence interval. Therefore, in this paper, we describe calculation of the d-statistic and its confidence interval directly from raw survey data following the methods of Morris and DeShon (2002), Nakagawa and Cuthill (2007), and Fritz, Morris and Richler (2012). The SAS Output Delivery System (ODS) is used to produce the d-statistic and its confidence interval. Three types of survey designs are considered: (a) Independent group single post-test (completely randomized) design; (b) Within-subject (one-group pretest–posttest) design, and (c) Independent-groups pretest–posttest design (IGPP). Finally, the authors present a SAS macro that implements the methodology for the d statistic and confidence interval for the three designs mentioned above. A basic understanding of SAS is sufficient to be able to use this macro, and without skill required in SAS macro programming. When the macro is invoked, a table with summary statistics, effect size, and confidence interval are calculated, and the results can be saved in Microsoft EXCEL format. This macro has been tested on Windows SAS 9.2.

Keywords: effect size, Cohen's **d-statistic**, confidence interval, Pre-Post Design, SAS macro

INTRODUCTION

Effect size estimates are used to measure, in a standardized manner, the magnitude of treatment effect or association between two or more variables. Cohen's d statistic (Cohen, 1988) is a widely used measure of effect size to compare two or more conditions, treatment versus control, for example. Within research settings in the biomedical and social sciences, three common designs to evaluate treatment effects or associations include: (a) Independent group single post-test (completely randomized) design; (b) Within-subject (one-group pretest–posttest) design, and (c) Independent-groups pretest–posttest design (IGPP). Whereas some professional journals explicitly require authors to supply effect sizes and corresponding confidence intervals (e.g. in addition to p-values) for results of comparisons of two or more groups (e.g. treatment effects), most published research articles do not provide standardized effect sizes. Moreover, the reporting of confidence intervals for estimates of effect size is even less frequent. Of note, providing estimates of effect size, whether for treatment comparisons of associations between variables, provides the direction and strength of association in a standard metric that is easily interpretable and also useful for meta-analysis. Perhaps a main reason for limited reporting of effect sizes is simply the lack of availability within popular statistical software packages. In general, researchers typically rely on a manual approach to calculate effect sizes and corresponding confidence intervals. Indeed, to our knowledge even in SAS, there is no standard procedure (PROC) that produces effect size (Cohen's d) along with its confidence interval.

Therefore, the primary purpose of this paper is to present a SAS macro that is used to calculate effect size and confidence interval from raw survey data (not summary statistics) collected using various study designs including: (a) Independent group single post-test design (IG design); (b) Within-subject (one-group pretest–posttest) design (RM design); and (c) Independent-group pre-test post-test design (IGPP design). In the following sections we discuss the data structure requirements and methods (formulas) used to calculate the effect size and its confidence interval for each design. Finally, we illustrate an example on how to invoke (call) the SAS macro to calculate the effect size and corresponding confidence interval.

EXAMPLE DATA: SURVEY DATA ON PSYCHOLOGICAL STATUS

To best explain the calculation of effect size (d) and its confidence interval, we use the following **long format** SAS data set from a fictitious study of psychological status. The snapshot of the psychological survey data is shown in Table 1 and includes only data from the first five subjects. In this data set, variable *ID* is used to identify the subject; *VISIT* variable has two values consisting of 1 (pre) and 2 (post); and the *GROUP* variable has two values consisting of 1(treatment) and 2(control). In addition, there are three continuous (dependent) variables for which we want to calculate the effect size. These three dependent variables are fictitious total scores on the 17-item PTSD-Checklist

(*PCL),* total score on the 18-item Brief Symptom Inventory (*BSI),* and total score on the 32-item self-reported Trauma Related Guilt Inventory (*TRGI*).

Within this framework, the following are required for operation of the SAS macro: (a) data must be in **long format**, as shown in the table 1; (b) all variables must be in numeric format; (c) the *GROUP* variable must have values 1 and 2 (e.g. treatment and control); and (d) the *TIME* variable (*VISIT* in the following example) must be specified as only 2 values (e.g. 1 and 2, or 1 and 3), although the data set can have more than two values (e.g. visit 1,2,3, etc). To calculate the effect size for the independent group single post-test design (IG design), we ignore the *VISIT* variable from the data set. Similarly, for the within-subject (one-group pretest–posttest) design (RM design), we ignore the *GROUP* variable. For the independent group pre-test posttest design (IGPP design), we use all columns from the data set. An efficient feature of this macro is that the effect size of more than one continuous dependent variable (for example PCL, BSI, and TRGI scores) can be simultaneously calculated.

ID	GROUP	VISIT	PCL	BSI	TRGI
2001	1	1	80	40	15
2001	1	2	74	41	14
2002	1	1	79	58	15
2002	1	2	39	13	6
2003	1	1	67	33	3
2003	1	2	59	38	3
2004	2	1	61	27	10
2004	2	2	55	26	13
2005	2	1	45	9	0
2005	2	2	37	9	0

Table 1: Example of Raw Survey Data

DESIGN 1: INDEPENDENT- GROUPS POST-TEST DESIGN (IG)

In the case of the independent-groups (IG) single post-test design, the effect size (Cohen's d) is simply the difference between the mean of the treatment group ($\overline{x}_2$) and control group ($\overline{x}_1$) divided by the standard deviation. In calculating the effect size, the macro assumes homogeneity of variances (i.e. both the control and treatment groups have the same underlying variance). The natural choice of variance in this case is the pooled standard deviation (s_p), which can be calculated using the equation (1) below.

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}} \tag{1}$$

This pooled standard deviation, s_p, is used to calculate the effect size using equation (2) below.

$$d_{IG} = \frac{\overline{x}_2 - \overline{x}_1}{s_p} \tag{2}$$

where $\overline{x}_1$ and $\overline{x}_2$ are sample means of group 1 (control group) scores and group 2 (treatment group) scores, respectively. Similarly, s_1^2 and s_2^2 are sample variances and n_1 and n_2 are sample sizes for each group. Invariably, it is also important to report a confidence interval for the effect size in addition to the point estimate. A confidence interval for this type of independent group single measure design can be calculated using equation (3) below.

$$CI_{d_{IG}} = (d_{IG} - z_{\frac{\alpha}{2}} \times se_d \,, d_{IG} - z_{\frac{\alpha}{2}} \times se_d) \tag{3}$$

where se_d is the estimate of standard error of the effect size (Hunter and Schmidt 2004; Nakagawa and Cuthill (2007) and is calculated using equation (4) below.

$$se_{d_{IG}} = \sqrt{\frac{(n_1 + n_2 - 1)}{(n_1 + n_2 - 3)}\left[\left(\frac{4}{n_1 + n_2}\right)\left(1 + \frac{d^2}{8}\right)\right]} \tag{4}$$

where $z_{\alpha/2}$ is the appropriate two-tailed value for the standard normal distribution (for example $z_{\alpha/2} = 1.96$ for 95% confidence interval) and $se_{d_{IG}}$ is the standard error of the d-statistic computed using equation (2).

Even though equation (1) calculates the d value by subtracting the mean of group 1 from the mean of group 2, the sign of *d* is arbitrary. When the direction of the result is consistent with the *a priori* hypothesis, it should be reported with a positive sign. When a result opposite the direction of that specified by the hypothesis, it should reported with a negative sign. This is easily accomplished by designating the group that is expected to have the higher mean as group 2.

To calculate the effect size and its confidence interval for this design, the macro is invoked (called), as in the following example. The user can replace all the parameter values, as in their data set. For example, SAS data SESUG12.survey_data can be replaced by their own SAS data. Details for calling the SAS macro are provided in the next section.

```
%effect_size( data=SESUG12.survey_data,idvar=id,groupvar=GROUP,
                    respvars=PCL BSI TRGI,ci=0.95)
```

DESIGN 2: ONE GROUP PRETEST–POSTTEST DESIGN (RM)

Paired sample *t*–tests compare group means when the two groups are related in various research designs, such as matched pairs and repeated measures. If a single group dependent variable is measured before and after treatment, the effect size (Cohen's *d*) is simply the mean difference between the pre- and post-test scores divided by the sample standard deviation of the change score, as provided in equation (5) per Morris and DeShon (2002).

$$d_{RM} = \frac{\overline{x}_2 - \overline{x}_1}{s_d} \qquad (5)$$

where $\overline{x}_2$ represents post treatment mean, $\overline{x}_1$ represents pre-treatment mean, and s_d represents the sample standard deviation of the change scores. Becker (1988) provided the following equation (6) to calculate the standard error of the effect size (Cohen's *d* statistic) for the paired design, which can be used to calculate a confidence interval.

$$se_{d_{RM}} = \sqrt{\frac{2(1 - r_{12})}{n} + \frac{d_{RM}^2}{2(n-1)}} \qquad (6)$$

The confidence interval for effect size d can be calculated using confidence interval equation (3) from the previous section replacing the corresponding values of effect size (d) and standard error of effect size for the paired design. In this equation, r_{12} is the correlation coefficient between the pre-test and post test scores.

Cohen (1988) suggested that calculation of effect size for the dependent paired group can be achieved using the same equation as the independent group design described above. In this case, the pooled standard deviation is calculated by equation (7) below.

$$s_p = \sqrt{\frac{s_1^2 + s_2^2}{2}} \qquad (7)$$

With this macro, users have the option to calculate effect size and its confidence interval using one of the two standard deviations (standard deviations of raw scores, or standard deviation of change score) in the denominator of equation (5). To calculate the effect size using the raw standard deviation, the user will use design 1 (design=1); to calculate the effect size using the standard deviation of the difference scores, the user will use design=2 when calling the SAS macro. This can be accomplished by use of the syntax example below. .

```
%effect_size(data=SESUG12.survey_data,idvar=id,design=1,timevar=VISIT,
                timeval1=1,timeval2=2,respvars=PCL BSI TRGI, ci=0.95)
```

Of note, the effect size calculation that uses the change score standard deviation is always greater than the effect size calculation from the raw standard deviation which suggests that the within-subject design is more powerful than the between-subject design (Feingold, 2009). Feingold (2009) also suggests that the effect size calculated using the raw standard deviation conveys the treatment potency.

DESIGN 3: INDEPENDENT-GROUPS PRETEST–POSTTEST DESIGN (IGPP)

In the case of the independent-group pretest-posttest design, different groups receive different treatments (e.g., experimental and control groups), and outcomes are measured both before and after the treatment. In this case, it is natural to calculate the effect size within each treatment condition, and then subtract the control group effect size from the experimental-group effect size as in equation (8) to compute the overall effect size (Becker, 1988).

The effect size for each treatment condition is defined as the pretest–posttest change in mean score divided by the standard deviation of raw score or change scores, as in the one group pre-post (RM) discussed in the previous section.

$$d_{IGPP} = \frac{\overline{x}_{Post,T} - \overline{x}_{Pre,T}}{s_T} - \frac{\overline{x}_{Post,C} - \overline{x}_{Pre,C}}{s_C} \qquad (8)$$

where s_T and s_C are the standard deviation of treatment group scores and control group scores, respectively. Both standard deviations (s_T and s_C) can be calculated either using raw scores (equation 7) or the change score of each group (treatment and control), as in the previous section.

Because of the complexity in calculating sampling variances of effect size estimates for the independent group pre-post (IGPP) design, only the approximation to the variance of the effect size is calculated, specifically, the sum of the variances for the two components (Becker, 1988; Morris and DeShon, 2002). The variance of each component of effect size can be calculated using equation (4) for the raw score case, and equation (6) if the change score standard deviation is used. This can be conducted for the treatment and control groups separately. The standard error of effect size for the IGPP design is simply the square root of the sum of variances (i.e. $se_{d_{IGPP}} = \sqrt{var(d_{IGPP})}$). The confidence interval for effect size d_{IGPP} can be calculated using equation (3) in the previous section replacing effect size and standard error from the $IGPP$ design.

In this IGPP design, as in the case of the within-subject repeated measure (RM) design, users have two options to calculate effect size and confidence interval using either the raw standard deviation or the standard deviation of the change scores. If the user wants to calculate the effect size and confidence interval using the raw standard deviation, *design*=1 should be selected as follows.

```
%effect_size(data=SESUG12.survey_data,idvar=id,design=1,groupvar=GROUP,
             timevar=VISIT,timeval1=1,timeval2=2,respvars=PCL BSI TRGI,cl=0.95)
```

If design = 1 is replaced by design=2 (keeping everything else the same) in the above macro call, the standard deviation of the change score will be used to calculate the effect size and confidence interval. As in the within-subject repeated measures design in the previous section, the effect size will always be higher if the standard deviation of the difference scores (post minus pre scores) is used instead of the raw scores (i.e. pooled standard deviation of pre-score and post-scores).

EFFECT SIZE CALCULATION MACRO PARAMETERS

The following are the macro parameters used for the effect size macro.

data   = name of SAS data set (long format)
idvar   = name of the variable for subject id
groupvar = name of group variable name (treatment/control group). If the design is single group (within-subject) pre-post or repeated measure (RM) design, leave this blank (values must be 1 or 2).
timevar   = name of time sequence variable (e.g. Visit=1 is pre and visit=2 is post). If the design is a single measure two group independent design (IG), leave this blank
respvars = name of the continuous dependent variable(s) for which to calculate the effect size(s). If there are more than one dependent variables, use a single space between each variable.
timeval1 = Values of time variable in the pre-visit (1 for pre-test for example)
timeval2 = Values of time variable in the post-visit (2 for post-visit for example)
cl   = confidence level (e.g. 0.95 to calculate 95% confidence interval)

HOW TO INVOKE THE SAS MACRO

Calling the effect size macro (provided in the Appendix) is straight-forward. The user specifies the library reference, dataset, and other parameters (*idvar*, *groupvar,* etc.) described above. Some parameters are specific to the three study designs (IG, RM, IGPP). For example, in the one group pretest-posttest design, macro parameter *groupvar* can be kept blank (i.e. *groupvar =)* or eliminated from the macro call (i.e. *%effect_size* statement). Once the macro codes are submitted (compiled), the macro can be invoked using the statement *%effect_size,* as in the example below. A table with summary statistics (sample size, mean, and standard deviation), effect size, and its confidence interval are calculated, and the results can be saved in Microsoft EXCEL.

Consider the case where we want to compare the pre- and post-treatment scores of several dependent variables (BDI, BSI, and TRGI scores) for a single group within-subject pre-post design. By supplying the macro call below, the effect size, 95% confidence interval, and summary statistics for the pre- treatment and post-treatment scores will be calculated (Table 2). Depending upon the study design, this table format will vary some but the effect size and confidence interval will always be produced. In the example below, the parameter *data* has the value **SESUG12.survey_data**. Please note in the following macro call (%effect_size) that SESUG12 is the SAS library name, and *survey_data* is SAS data set name. In this case, the macro parameter *groupvar* is ignored from the parameter list, as we are interested in calculating the effect size for the single group within-subject pre-post or repeated measure (RM) design. The first column of the results table (column name measure) indicates the direction of the effect size calculated. In this example, PCL2-PCL1 (PCL2 minus PCL) indicates that the pre-test mean is subtracted from the post-test mean to calculate the numerator of the effect size.

```
%effect_size(data=SESUG12.survey_data,idvar=id,design=1,timevar=VISIT,
             timeval1=1,timeval2=2,respvars=PCL BSI TRGI, cl=0.95)
```

Response	Sample Size (n)	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Effect Size (d)	95% Conf. Interval
PCL2-PCL1	29	58.6	16.41	48.62	19.41	-0.556	(-0.870,-0.242)
BSI2-BSI1	29	28.07	17.48	17.41	17.41	-0.611	(-1.002,-0.220)
TRGI2-TRGI1	30	7.73	4.95	6.63	4.75	-0.227	(-0.546,0.093)

Table 2: Effect Size For Single Group Pre-Test/Post Test Design

CONCLUSION

The calculation of effect size and corresponding confidence interval based on a user-friendly SAS macro is presented. This macro can be used to calculate the effect size for one or more continuous response (dependent) variables for three types of study designs; (a) Independent group single post-test (completely randomized) design; (b) Within-subject (single-group pretest–posttest) design; and (c) Independent-group pretest–posttest design (IGPP). Individuals with a basic working knowledge of SAS programming and statistical understanding of effect size calculation (and interpretation) should be able to use this macro with minimal difficulty. A requirement of this macro is that data set has to be structured in the **long format**, and values of the group variable and time variable have to be coded with values of 1 and 2 respectively. In addition, a limitation of this macro is that small sample bias correction is not implemented when calculating the effect size and confidence interval.

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Contact Information

Your comments and questions are valued and encouraged. Contact the authors at:

Rajendra Kadel, Ph. D. Candidate of Biostatistics
University of South Florida
College of Public Health
13201 Bruce B Downs, MDC56
Tampa, Florida 33612
rkadel@health.usf.edu

Kevin E. Kip, Ph.D., FAHA
Professor and Executive Director, Research Center,
University of South Florida,
College of Nursing
12901 Bruce B. Downs Blvd.
Tampa, FL 33612-4476
kkip@health.usf.edu

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APPENDIX B: SAS MACRO

```
******************************************************************************;
** Brief Introduction to Macro:                                            **
** -------------------------                                               **
** Purpose of this macro is to calculate effect size (Cohen's d)           **
** and its confidence interval as well as summary statistics               **
** (sample size, mean, standard deviation) for one or more continuous      **
** dependent variables . Three types of designs are considered:            **
**      (a) Independent group post-test (completely randomized) design (IG) **
**      (b) Within-subject (one-group pretest-posttest) design, and (RM)   **
**      (c) Independent-groups pretest-posttest design (IGPP)              **
** In case of designs (b) and (c), two types of standard deviations        **
** (denominator of effect size formula) are used to calculate effect size  **
** (i) using raw standard deviation or (ii) using standard deviation       **
** of difference scores( difference of pre post scores).                   **
**                                                                         **
** How to Cite this Macro:                                                 **
** ----------------------                                                  **
** Kadel R. P., Kip K. E. (2012). A SAS Macro to Compute Effect Size       **
** (Cohen's d) and its Confidence Interval from Raw Survey Data.           **
** Proceedings of the annual Southeastern SAS Users Group Conference.      **
** -------------------------------------------------------------------------**
** Contact Address for comments/Feedback/Suggestions about Macro:          **
** -------------------------------------------------------------           **
**      Rajendra Kadel, at rkadel@health.usf.edu                           **
**                                                                         **
******************************************************************************;


%macro  effect_size( data,idvar,design,groupvar, timevar,
                 timeval1, timeval2,respvars,cl=0.95);
    **************************************************:
    ** case I: independent group post test design***;
    ** In this case timevar will be blank***********;
    **************************************************;
    data _null_;
        call symput("conf","&cl"*100);
    run;
    %if &timevar= %then %do;
        proc sql noprint;
            select distinct(&groupvar) into :grp1-:grp2 from &data;
        quit;
        proc sort data=&data out=data1(keep=&idvar &groupvar &respvars);
            by &groupvar;
        run;
        **** mean ****;
        ods trace on;
        proc means data=data1 mean;
        by  &groupvar;
        var  &respvars;
        ods output Summary=Summary_mean;
        run;
        ods trace off;
        **** sd ****;
        proc means data=data1 std;
        by  &groupvar;
        var &respvars ;
        ods output Summary=Summary_std;
        run;
        **** N ****;
        proc means data=data1 n;
        by  &groupvar;
        var &respvars;
```

```
    ods output Summary=Summary_n;
    run;
    ** transpose data***;
    proc transpose data=summary_mean out=mean_long(rename=(_LABEL_=static))
        name=Measure prefix=&groupvar;
        id &groupvar;
    run;
    proc transpose data=summary_std out=std_long(rename=(_LABEL_=static))
        name=Measure prefix=&groupvar;
        id &groupvar;
    run;
    proc transpose data=Summary_n out=n_long(rename=(_LABEL_=static))
        name=Measure prefix=&groupvar;
        id &groupvar;
    run;
    ** merge data***;
    data combined_withingroup_IG;
    merge mean_long(keep=measure &&groupvar.&grp1 &&groupvar.&grp2
            rename=(&&groupvar.&grp1=mean&grp1 &&groupvar.&grp2=mean&grp2))
        std_long(keep=&&groupvar.&grp1 &&groupvar.&grp2
            rename=(&&groupvar.&grp1=sd&grp1 &&groupvar.&grp2=sd&grp2))
        n_long(keep=&&groupvar.&grp1 &&groupvar.&grp2
            rename=(&&groupvar.&grp1=n&grp1 &&groupvar.&grp2=n&grp2)) ;
    run;
    *** Calculate effect size and CI***;
    *** S.E. of effect size calculate using eqn 16 of Nakagawa & Cuthill (2007)*;
    data effectsize_table_IG;
        retain measure n&grp1 mean&grp1 sd&grp1 n&grp2 mean&grp2
            sd&grp2 eff_size ci_low ci_up;
        set combined_withingroup_IG;
        M_Change=(mean&grp2-mean&grp1);
        SD_pool=sqrt((((n&grp1-1)*sd&grp1**2)+
                    ((n&grp2-1)*sd&grp2**2))/(n&grp1+n&grp2-2));
        eff_size=M_Change/SD_pool;
        ** Standard error of d**;
        se_d1=((n&grp1+n&grp2-1)/(n&grp1+n&grp2-3));
        se_d2= 4/(n&grp1+n&grp2);
        se_d3=1+eff_size**2/8;
        se_d= sqrt(se_d1*se_d2*se_d3);
        z=PROBIT(.50+&cl/2);
        ci_low=eff_size-z*se_d;
        ci_up=eff_size+z*se_d;
        format _NUMERIC_ 8.3;
        format n&grp1 n&grp2 8.0 mean&grp1 sd&grp1 mean&grp2 sd&grp2 8.2;
    drop se_d1 se_d2 se_d3 z se_d M_Change SD_pool;
    run;
%goto printresult;
%end;


********************************************************************;
** case II: One group pre-post or repeated measure (RM) design**;
** In this case Group variable will be blank*******************;
********************************************************************;
%macro eff_size_paired(data=,idvar=,design=2,timevar=,timeval1=,
                    timeval2=,respvars=,cl=,outdata=);
    ** create macro variables***;
    data _null_ ;
        call symput('nresp',countw("&respvars"));
    run;
    %let respvars=&respvars;
    %let nresp=&nresp;
    data _null_;
        %do i=1 %to %eval(&nresp);
            call symputx("resp&i",scan("&respvars",&i,''));
        %end;
    run;
    *** create table with distinct values***;
```

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```
proc sort data=&data out=data2(keep=&idvar &timevar &respvars) nodupkey;
by &idvar &timevar;
run;
** make data wide***;
%do i=1 %to %eval(&nresp);
    Proc SQL;
        create table survey_wide&i as
        select distinct a.&idvar,
        (Select b.&&resp&i from data2 as b where b.&timevar=&timeval1
            and a.&idvar=b.&idvar) as &&resp&i..&timeval1,
        (Select c.&&resp&i from data2 as c where c.&timevar=&timeval2
            and a.&idvar=c.&idvar ) as &&resp&i..&timeval2,
        calculated &&resp&i..&timeval2 - calculated &&resp&i..&timeval1
            as &&resp&i.._diff from data2 as a where a.&timevar=&timeval2;
    quit;

    ods trace on;
    proc corr data=survey_wide&i pearson;
    var &&resp&i..&timeval1 &&resp&i..&timeval2;
    ods output  Corr.PearsonCorr=corr;
    run;
    ods trace off;
    * create macro variable for correlation**;
    proc sql noprint;
        select &&resp&i..&timeval2 into :r
        from work.corr where variable="&&resp&i..&timeval1";
    quit;
    * create table for effect size (using SD of difference score)******;
    ** SE of effect size calculate using Nakagawa & Cuthill,2007 eq(18))*;
    %if &design=2 or &design=  %then %do;
        proc sql ;
            create table eff_table&i as
            select min(count(&&resp&i..1),
            count(&&resp&i..&timeval2)) as  n ,
            mean(&&resp&i..1) as mean1,
            std(&&resp&i..&timeval1) as sd1 format=8.2,
            mean(&&resp&i..2) as mean2,
            std(&&resp&i..&timeval2) as sd2 format=8.2,
            mean(&&resp&i..&timeval2-&&resp&i..&timeval1)
                as mean_dif format=8.2,
            std(&&resp&i.._diff) as sd_dif format=8.2,
            (calculated mean_dif) /(calculated sd_dif) format=8.3
                as effect_size from survey_wide&i;
        quit;
    %end;
    ** cohen (1988) suggested to use pooled standard deviation from raw scores
;

    %if &design=1 %then %do;
        proc sql ;
            create table eff_table&i as
            select min(count(&&resp&i..1),
            count(&&resp&i..&timeval2)) as  n ,
            mean(&&resp&i..1) as mean1,std(&&resp&i..&timeval1) as sd1,
            mean(&&resp&i..2) as mean2,std(&&resp&i..&timeval2) as sd2,
            mean(&&resp&i..&timeval2-&&resp&i..&timeval1) as mean_dif,
            std(&&resp&i.._diff) as sd_dif format=8.2,
            sqrt(((calculated sd1)**2*(count(&&resp&i..1)-1)+(calculated
            sd2)**2*
            (count(&&resp&i..2)-1))/(count(&&resp&i..1)+count(&&resp&i..2)-2))
            as sd_pool,
            (calculated mean2- calculated mean1) /(calculated sd_pool)
            format=8.3 as effect_size
            from survey_wide&i;
        quit;
    %end;
    *create table for each response**;
    data eff_table&i;
```

```
            retain Response n mean1 sd1 mean2 sd2 tval pval effect_size ci_low
            ci_up;
            length Response $10.;
            set eff_table&i;
            Response="&&resp&i";
            se_d= sqrt(2*(1-&r)/n+(effect_size**2)/(2*(n-1)));
            /* z=quantile('NORMAL',.975); also gives same*/
            z=PROBIT(.50+&cl/2); /* probit returns quantiles (zscore) */
            ci_low=effect_size-z*se_d;
            ci_up=effect_size+z*se_d;
            format _NUMERIC_ 8.3;
            format n 8.0 mean1 sd1 mean2 sd2 tval 8.2;
            *drop se_d t mean_dif sd_dif;
            drop z;
        run;

    %end;
    *** collecting effect size and confidence interval for all values***;
    data &outdata;
        set
        %do i=1 %to %eval(&nresp);
        eff_table&i
        %end;;
    run;
%mend eff_size_paired;
*** to calculate effect size for paired t-test design***;
%if &groupvar= %then %do;
    %eff_size_paired(data=&data,idvar=&idvar,design=&design,
        timevar=&timevar,timeval1=&timeval1, timeval2=&timeval2,
        respvars=&respvars,cl=&cl,outdata=effectsize_table_RM)
%put "Design &design";
%end;
*****************************************************************;
** case II: Independent Group Pre-Post (IGPP)design**************;
** Provide *rovide the name of group and time variable***********;
*****************************************************************;
%if &groupvar^= and &timevar^= %then %do;
        proc sql noprint;
        select distinct(&groupvar) into :grp1-:grp2 from &data;
    quit;
    ** to calculate effect size of 2-group pre-post design***;
    ** make two separate data set for group 1 and group 2****;
    data data_&grp1(keep=&idvar &timevar &respvars) data_&grp2(keep=&idvar
            &timevar &respvars);
        set &data;
        if &groupvar=&grp1 then output data_&grp1;
        if &groupvar=&grp2 then output data_&grp2;
    run;
    * Noow calculate effect size for both groups*********************;
    * using either design 1(independent) or design 2 paired desig)***;
    %eff_size_paired(data=data_&grp1,idvar=&idvar,design=&design,
        timevar=&timevar,timeval1=&timeval1, timeval2=&timeval2,
        respvars=&respvars,cl=&cl,outdata=effectsize_table&grp1)
    %eff_size_paired(data=data_&grp2,design=&design,idvar=&idvar,
        timevar=&timevar,timeval1=&timeval1, timeval2=&timeval2,
        respvars=&respvars,cl=&cl,outdata=effectsize_table&grp2)

    * combine two tables to get effect size***;

    * IGPP design is square root of sum of variance ****;
    proc sql;
    create table effectsize_table_IGPP as
        select  trim(a.Response) ||"&grp1"||"-"||trim(a.Response)||"&grp2" as
        Response,
        a.n as n_&grp1,
        a.mean1 as M1_&grp1 format 8.2, a.sd1 as SD1_&grp1 format=8.2,
        a.mean2 as M2_&grp1 format=8.2, a.sd2 as SD2_&grp1 format=8.2,
```

```
            b.n as n_&grp2,
            b.mean1 as M1_&grp2 format=8.2,
            b.sd1 as SD1_&grp2 format=8.2,  b.mean2 as M2_&grp2 format=8.2,
            b.sd2 as SD2_&grp2 format=8.2,  a.effect_size - b.effect_size as eff_size,
            calculated eff_size-PROBIT(.50+&cl/2)*(sqrt(a.se_d**2+b.se_d**2)) as
            CI_LOW,
            calculated eff_size+PROBIT(.50+&cl/2)* (sqrt(a.se_d**2+b.se_d**2)) as
            CI_UP
        from work.effectsize_table&grp1 as a, work.effectsize_table&grp2 as b
        where a.Response=b.response;
        quit;
    %goto printresult;
    %end;
    ** calculate macro variable for confidence level***;

    %printresult:
    ** Print results***;
    ods html file="survey_data_eff_size.xls";
    %if &timevar= %then %do;
        title "Table 1: Effect Size (Cohen'd) and its Confidence Interval
                for Independnt Group Post-Test Design(IG).";
        proc sql nonumber;
        select  trim(measure) ||"&grp2"||"-"||trim(measure)||"&grp1" as Response,
            n1 label="Group&grp1 Sample Size (n1)",mean1 label="Group&grp1 mean",
            sd1 label="Group&grp1 SD",
            n2 label="Group&grp2 Sample Size (n2)", mean2 label="Group&grp2 Mean",
            sd2 label="Group&grp2 SD",eff_size format=8.3 label="Effect Size (d)",
            "("||trim(left(put(ci_low,8.3)))||","||trim(left(put(ci_up,8.3)))||")"
                label="&conf % Conf. Interval"
            from work.effectsize_table_IG;
        quit;
        title;
    %end;
    %if &groupvar=  %then %do;
        title "Table 1: Effect Size (Cohen'd) and its Confidence Interval
                for Paired or Repeated Measured(RM) Design";
        proc sql nonumber;
        select  trim(Response) ||"&timeval2"||"-"||trim(Response)||"&timeval1" as
Response,
            n as n label="Sample Size (n)", mean1 label="Pre-test Mean",
            sd1  label="Pre-test SD",mean2 label="Post-test Mean",
            sd2  label="Post-test SD", effect_size format=8.3 label="Effect Size
            (d)",
            "("||trim(left(put(ci_low,8.3)))||","||trim(left(put(ci_up,8.3)))||")"
                label=" &conf% Conf. Interval"
            from work.effectsize_table_RM;
        quit;
        title;
    %end;

    %if &groupvar^= and &timevar^= %then %do;
        title "Table 1: Effect Size (Cohen'd) and its Confidence Interval
            for Independent Group Pretest Posttest Design(IGPP)";
        proc sql nonumber;
        select * from work.effectsize_table_IGPP;
        quit;
        title;
    %end;
    ods  html close;
%mend effect_size;

**  Examples:Invoking macro to calculaate effect sizes **;
*** Independent 2 group design ***;
%effect_size( data=SESUG12.survey_data,
            idvar=id,
            groupvar=GROUP,
            respvars=PCL BSI TRGI CESD,
```

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```
                cl=0.95)
*** Repeated (sd calculated from indep. design) design ***;
%effect_size(data=SESUG12.survey_data,
                idvar=id,
                design=1, /* 1 is 2-group independent,  2 is pre-post */
                groupvar=, /* or completely remove groupvar from list */
                timevar=VISIT,
                timeval1=1,
                timeval2=2,
                respvars=PCL BSI TRGI CESD,
                cl=0.95)
** Repeated (sd calculated from change scores) design ***;
%effect_size(data=SESUG12.survey_data,
                idvar=id,
                design=2, /* 1 is 2-group independent,  2 is pre-post */
                groupvar=, /* or completely remove groupvar from list */
                timevar=VISIT,
                timeval1=1,
                timeval2=2,
                respvars=PCL BSI TRGI CESD,
                cl=0.95)
** Ind. Group Pre-Post design: (sd calculated from change scores) ***;
%effect_size(data=SESUG12.survey_data,
                idvar=id,
                design=1,
                groupvar=GROUP,
                timevar=VISIT,
                timeval1=1,
                timeval2=2,
                respvars=PCL BSI TRGI CESD,
                cl=0.95)
** Ind. Group Pre-Post design: : design=2 (sd calculated from change scores)*;
%effect_size(data=SESUG12.survey_data,
                idvar=id,
                design=2, /* 1 is 2-group independent,  2 is pre-post */
                groupvar=GROUP,
                timevar=VISIT,
                timeval1=1,
                timeval2=2,
                respvars=PCL BSI TRGI CESD,
                cl=0.95)
```