

# 1 Introducing Meta-Analysis and *Meta-Stat*

This chapter introduces meta-analysis and the *Meta-Stat* program.

## Introducing Meta-Analysis

Research literature, it is often pointed out, is growing at an exponential rate. A recent study estimated that there are 40,000 journals for the sciences, and that researchers are filling those journals at the rate of one article every 30 seconds, 24 hours a day, seven days a week (Mahoney, 1985). No matter what the topic—from computer-aided instruction to sex differences to the effects of medication on hyperactivity—researchers can, in just a few years, add dozens and even hundreds of studies to the literature.

As research results accumulate, it becomes increasingly difficult to understand what they tell us. It becomes increasingly difficult to find the knowledge in this flood of information.

In 1976, Gene Glass proposed a method to integrate and summarize the findings from a body of research. He called the method **meta-analysis**. Meta-analysis is the statistical analysis of a collection of individual studies.

*Meta-analysis refers to the analysis of analyses. I use it to refer to the statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings. It connotes a rigorous alternative to the casual, narrative discussions of research studies which typify our attempts to make sense of the rapidly expanding research literature. (Glass, 1976)*

## The Traditional Approach to Research Integration

Using the traditional method of integrating research studies, a reviewer provides a narrative, chronological discourse on previous findings. Yet this method is flawed and inexact:

- ! Unable to deal with the large number of studies on a topic, reviewers focus on a small subset of studies, often without describing how the subset was selected.
- ! Reviewers often cite the conclusions of previous reviews without examining those reviews critically.
- ! Reviewers are usually active and prominent in the field under review. Therefore, they might not be inclined to give full weight to evidence that is contrary to their own positions.

## The Meta-Analysis Approach to Research Integration

In a meta-analysis, research studies are collected, coded, and interpreted using statistical methods similar to those used in primary data analysis. The result is an integrated review of findings that is more objective and exact than a narrative review.

## Solving the Complexity Problem

The human mind is not equipped to consider simultaneously a large number of alternatives. (This is true even for bright, energetic researchers.) Confronted with the results of 20 similar studies, the mind copes only with great difficulty. Confronted with 200, the mind reels. Yet that is exactly the scope of the problem faced by a researcher attempting to integrate the results from a large number of studies. As a result,

*The typical review concludes that the research is in horrible shape; sometimes one gets results, sometimes one doesn't. Then the call is sounded for better research designs, better measures, better statistical methods—in short, a plaintive wish that things were not so complicated as they are. (Glass, 1976)*

When performed on a computer, meta-analysis helps the reviewer surmount the complexity problem. The reviewer can code hundreds of studies into a data set.

The data set can then be manipulated, measured, and displayed by the computer in a variety of ways.

## Solving the Ambiguity Problem

Researchers can tolerate ambiguity well. Policy makers, however, particularly elected policy makers, have a limited time in which to act. They look to research to provide information that will help them choose among policy options.

Unfortunately, original research, and narrative reviews of the research, often do not provide clear options to policy makers. Senator Walter Mondale expressed his frustration to the American Psychological Association in 1970:

*What I have not learned is what we should do about these [educational] problems. . . . For every study, statistical or theoretical, that contains a proposed solution or recommendation, there is always another equally well-documented study, challenging the assumptions or conclusions of the first. No one seems to agree with anyone else's approach. But more distressing: no one seems to know what works.*

## Solving the Replication Problem

A scientific study should be designed and reported in such a way that it can be replicated by other researchers. However, researchers seldom attempt to replicate previous findings. Instead, they pursue funding for the new, the novel, or—at the very least—they attempt to extend what is considered to be the current state of knowledge in their field. The result can be an overwhelming number of studies on a given topic, with no two studies exactly alike.

In such circumstances, it is difficult to determine if the differences between the study outcomes are due to chance, to inadequate study methods, or to systematic differences in the characteristics of the studies.

Meta-analysis can help you investigate the relationship between study features and study outcomes. You code the study features according to the objectives of the review. You transform the study outcomes to a common metric so that you can compare the outcomes. Last, you use statistical methods to show the relationships between study features and outcomes.

## Introducing *Meta-Stat*

*Meta-Stat* is a computer program that automates the many complex tasks that are required to perform a meta-analysis. With *Meta-Stat*, you can:

- ! Code the features of each study

- ! Transform study findings into a common metric, called the **effect size**, so that the studies can be compared
- ! Apply statistical techniques to the data
- ! Display the data on a variety of charts

The following sections provide an overview of *Meta-Stat*.

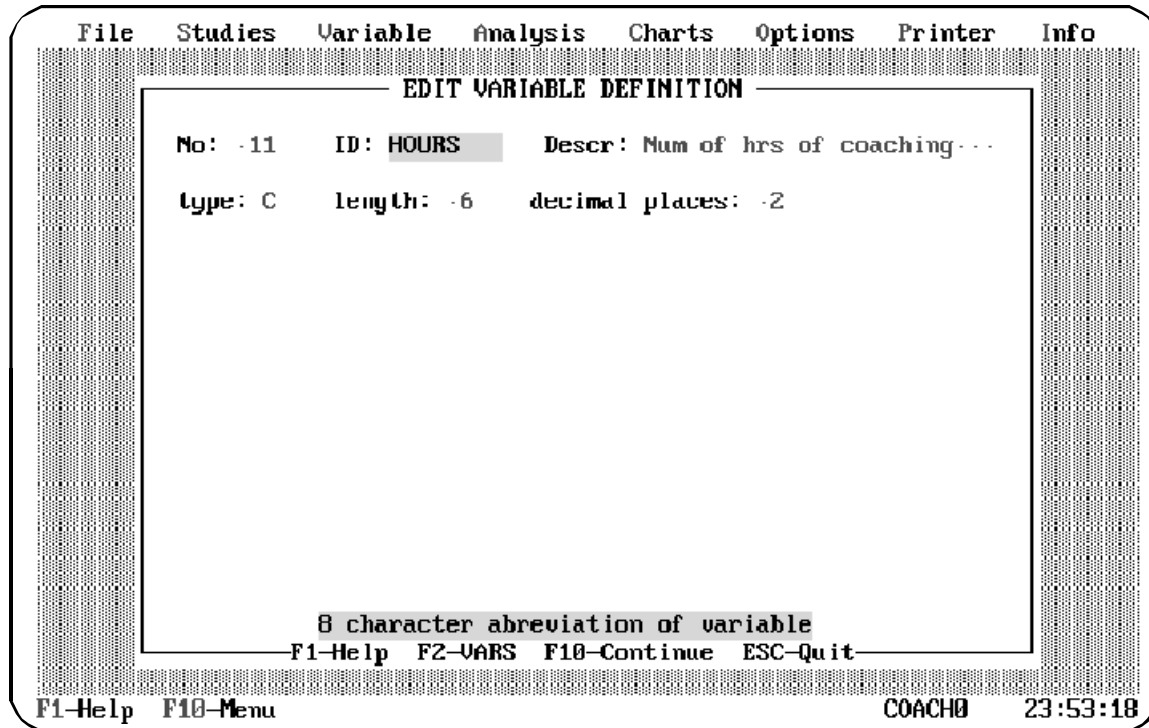
## Coding Study Features

One of your first tasks will be to create variables with which you can code study features. *Meta-Stat* offers 10 variables as a starting point, including:

- ! Effect size
- ! Unbiased effect size
- ! Sample size

You can create your own variables to identify features of the studies. For example, suppose you are reviewing studies that investigate the effects of pre-test coaching on Scholastic Aptitude Test scores. You would probably need to create a variable

to identify the number of hours of coaching:



You can also create variables to track the characteristics of the studies in your meta-analysis. For example, suppose you want to analyze the relationship between study outcomes and study quality. You can create a variable to identify the quality of each study. In this example, the variable can identify up to three levels of quality:

```
File  Studies  Variable  Analysis  Charts  Options  Printer  Info
-----
                        EDIT NEW VARIABLE
-----
No: .20   ID: QUALITY.  Descr: Quality rating.....
Type: D
Grp Labels
1: Low.....
2: Average...
3: High.....
4: .....
5: .....
6: .....
7: .....
8: .....
9: .....
label for data values
-----F1-Help  F2-VARS  F10-Continue  ESC-Quit-----
F1-Help  F10-Menu                                COACH  9:08:39
```

After creating the variables you need, you use the variables to code the features of each study. The following example shows the entry screen you use to enter data about each study:

File	Studies	Variable	Analysis	Charts	Options	Printer	Info
STUDY ID: ALLEN		TITLE: Effectiveness of study counseling					
STUDY NUM: 1 of 31		AUTHORS: Allen, G. J.					
1	EFFECTSZ	Effect Size					0.918...
2	UNBIASED	Unbiased Effect Size					0.909
		(1 - (3 / ((4 * TOTAL_N) - 9))) * EFFECTSZ					
3	EFF3R_GP	Effect size source ; 1=Correlation; 2=T-Statistic;					
		3-T-Statistic; 4-Chi-Square; 5-Probability Level;					
		6-Standardized Difference; 7-Direct Entry; 8-Gain					
		Scores (parametric)					2
4	EFF_CLTR	Effect size cluster					0
5	PUB_YR	Publication Year					67
6	EXP_N	Experimental Group Size					41
7	CTRL_N	Control Group Size					40
8	TOTAL_N	Total Sample Size					81
		EXP_N + CTRL_N					
9	WEIGHT	Inverse of the variance					18.351
		(2 * TOTAL_N * EXP_N * CTRL_N) / ((2 * SQR(TOTAL_N)) + (EXP_N * CTRL_N * SQR(UNBIASED)))					
10	PUBTY_GP	Publication Type ; 1=journal; 2=dissert; 3=paper;					
		4=book; 5=other					2
11	HOURS	Num of hrs of coaching					
F1-Help F7-Back F8-Next F10-Menu				VAR 1 of 19		COACH0	23:53:58

### Transforming Study Results into Effect Sizes

In addition to coding the features of each study, you must also code the results. Because results can be reported in different ways in different studies, *Meta-Stat* allows you to enter the outcome statistics as reported in the original studies.

*Meta-Stat* transforms the outcome statistic into the **effect size**. The effect size is the standardized difference between the means of the treatment group and the control group or between the means of two treatment groups. You can read more about the effect size in Chapter 6.



Some study results are more properly described with correlational coefficients, differences between percents, or even odds ratios. *Meta-Stat* can also analyze correlations and has routines for correct for several attenuating factors. The plain statistics option can be used for analyzing other types of data.

In the following example, *Meta-Stat* will calculate the effect size from the F statistic reported in the original study.

```

File  Studies  Variable  Analysis  Charts  Options  Printer  Info
STUDY ID: ALLEN      TITLE: Effectiveness of study counseling
STUDY NUM: 1 of 31  AUTHORS: Allen, G. J.
1 EFFECTSZ Effect Size                ---0.918
2 UNBIASED Unbiased Effect Size
      (1 - (3 / ((4 * TOTAL_N) - 9))) * EFFECTSZ      ---0.909
3 EFF3R_GP Effect size source ; 1=Correlation; 2=T-Statistic;
      EFFECT SIZE - F STATISTIC      -Probability Level;
      Direct Entry; 8=Gain
      ->F Statistic:                2
      Degrees of freedom:          67
      Direction:                   positive          41
      F1-Help ESC-Quit Enter-Select F10-Done      81
9 WEIGHT Inverse of the variance
      (2*TOTAL_N*EXP_N*CTRL_N) / ((2*SQR(TOTAL_N)) + (EXP_N*
      CTRL_N*SQR(UNBIASED)))      ---18.351
10 PUBTY_GP Publication Type ; 1=journal; 2=dissert; 3=paper;
      4=book; 5=other                2
11 HOURS Num of hrs of coaching
      F1-Help F7-Back F8-Next F10-Menu          UAR 1 of 19  COACH0  23:54:09
  
```

## Applying Statistical Techniques to Your Data

After you enter the coded study features, *Meta-Stat* can help you uncover the secrets in your data by applying a full set of statistical techniques.

You can display simple descriptive statistics. This example shows descriptive statistics for the Effect Size variable from a particular meta-analysis:

```

META-STAT 09/10/93
----- DESCRIPTIVE STATISTICS -----
Criterion Variable: UNBIASED Unbiased Effect Size
Weighting Variable:
Select If:

Number of Valid Observations: 29
Number of Missing Observations: 1

                unweighted
-----
Mean           0.591
Median        0.479
Variance      0.376
Stand. Dev.   0.613
Min Value    -0.287
Max Value    2.087
Range        2.374

Hedges's Ht   116.965 (p = 0.000)

Ctrl-P Print  F10 Menu  ↑↓ next variable  PgDn more 22:14:26
    
```

You can obtain a host of statistics that are described in the meta-analysis literature as show on the following screen:

```
META-STAT                                09/10/93
----- DESCRIPTIVE STATISTICS -----
Criterion Variable:  UNBIASED  Unbiased Effect Size
Weighting Variable:
Select If:

Number of Valid Observations:    29
Number of Missing Observations:  1

                                unweighted
-----
Mean ES                          0.591
Fisher's Z                       1.497 (p=0.13)
Equiv ES                          0.579
Equiv R                          0.278
Equiv R SQ                       0.077
Failsafe N                        0
Var Ratio                         3.750

Ctrl-F Print  F10 Menu  f↓ next variable  PgUp basic                                22:15:12
```

Using Regression analysis, you can perform regression calculations using any predictor variables that you choose:

```

META-STAT 09/10/93
----- REGRESSION -----
Criterion Variable: UNBIASED Unbiased Effect Size
Predictor Variables: HOURS
Weighted by: WEIGHT Inverse of the variance
Listwise deletion
Solution took 1 iterations

Multiple R 0.7706 R Square 0.5939
Adjusted R-Square 0.5776 Standard Error 1.3637

|                   | <b>DF</b> | <b>Sum of squares</b> |  | <b>Mean square</b> | <b>p</b>      |
|-------------------|-----------|-----------------------|--|--------------------|---------------|
| <b>Regression</b> | <b>1</b>  | <b>67.9878 Q(R)</b>   |  | <b>67.9878</b>     | <b>0.0000</b> |
| <b>Residual</b>   | <b>25</b> | <b>46.4942 Q(E)</b>   |  | <b>1.8598</b>      | <b>0.0001</b> |

Ctrl-P Print F10 Menu PgDn More 22:16:20
    
```

You can study the differences between groups. In the following example from the Group Means analysis, *Meta-Stat* has calculated the effect size mean, standard deviation, and 95 percent confidence intervals for a grouping variable called Publication Type. This variable identifies where a study was published:

**META-STAT** **09/10/93**

---

**GROUP MEANS**

---

**Criterion Variable: UNBIASED**

PUBYRGRP	Year of publication	Mean	St. Dev.	N	95% Confid Interval
1	60-70	1.146	0.413	5	0.671 to 1.620
2	71-75	0.532	0.534	5	-0.081 to 1.146
3	76-80	0.557	0.673	15	0.187 to 0.928
4	81+	0.097	0.260	4	-0.264 to 0.458

**Hedges's Homogeneity Tests**

Source	Statistic	df	
Total	116.965	28	(p = 0.000)
Within	97.591	25	(p = 0.000)
Between	19.373	3	(p = 0.000)

**Ctrl-F Print F10 Menu** **22:19:45**

You can also tell *Meta-Stat* to create dummy variables from a grouping variable. This allows you to explore the differences between the groups identified by that variable. The following example shows regression results for which dummy variables were created from the variable Publication Type. The results allow you to compare studies based on where the studies were published:

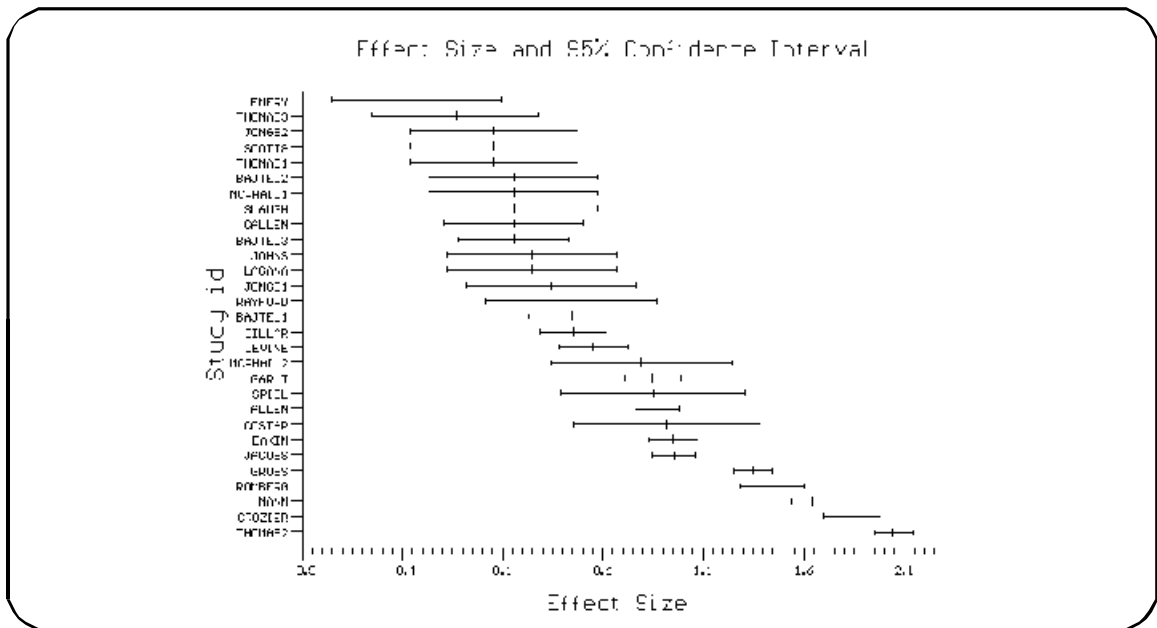
META-STAT		REGRESSION					09/10/93
Variable		Beta	B	St Err	t	p	
PUBTY_GP	journal	0.212	0.281	0.344	0.817	0.580	
PUBTY_GP	dissert	0.307	0.451	0.351	1.285	0.197	
PUBTY_GP	paper	0.206	0.325	0.355	0.914	0.636	
PUBTY_GP	other	0.462	1.377	0.426	3.230	0.002	
Constant			0.508	0.414	1.226	0.219	

Standard errors follow Hedges and Olkin (1985, pages 167-188).

Ctrl-F Print F10 Menu PgUp,PgDn More 22:21:26

## Displaying Results

*Meta-Stat* can display your data on a variety of charts. For example, you can show the effect size and 95 percent confidence intervals for each study:



A wide range of graphic options are available.