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ABSTRACT

The meta-analytic techniques of G. V. Glass (1976) and J. E. Hunter and F. L. Schmidt (1977) were compared through their application to three meta-analytic studies from education literature. The following hypotheses were explored: (1) the overall mean effect size would be larger in a Hunter-Schmidt meta-analysis (HSMA) than in a Glass meta-analysis (GMA) due to correction for measurement error when compared on the same set of experimental data; (2) the overall mean effect size calculated using the pooled within-group standard deviation in HSMA would not differ significantly from that in a GMA that uses the control group standard deviation; (3) most of the variation between study effect sizes would be due to sampling error according to sampling error correction formulas from the HSMA method; and (4) no moderator variables would be found because most of the variation between study effect sizes is due to sampling error. A correlated t-test was used to compare the overall mean effect sizes that were calculated using GMA and HSMA. Pearson correlations and analyses of variances were run on the study data. Three meta-analytic studies were selected and statistical data from each of the individual studies were collated. Results support Hypotheses 1 and 2, but reject Hypotheses 3 and 4. It is argued that the HS correction formulas are technically more accurate, but that the Glass method is adequate in portraying effect size and more easily calculated. Three tables present data from the meta-analyses. A 21-item list of references is included. (SLD)

A COMPARISON OF THE GLASS META-ANALYTIC TECHNIQUE WITH THE HUNTER-SCHMIDT META-ANALYTIC TECHNIQUE ON THREE STUDIES FROM THE EDUCATION LITERATURE

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Introduction

Background on Meta-Analysis

Since the 1970's, various quantitative methods have been introduced by researchers to solve the problem of integrating a body of literature containing many studies. Gene V. Glass (1976) coined the term "meta-analysis" to describe the "analysis of analyses, or the statistical analysis of a large collection of analysis results from independent studies for the purpose of integrating the findings" (p. 3). The Glass technique has been widely applied in the field of education (Walberg, 1986).

The following year, Schmidt and Hunter (1977) reported on a technique called "Validity Generalization", which was a meta-analytic technique that differed somewhat from the Glass technique. Hunter, Schmidt, and Jackson (1982) believe their "validity generalization" technique is "state of the art meta-analysis . . . . . the most complete meta-analysis procedure now known" (p. 140). The Hunter-Schmidt technique was developed in the area of personnel psychology and has primarily been used in the area of psychology (Schmidt and Hunter, 1977).

The APA Monitor reports that 600 to 800 meta-analyses have been done in the area of psychology since meta-analytic technique was developed, with the primary methods used being the Hunter-Schmidt method and the Glass method (Adler, 1990). In the area of education, the Hunter-Schmidt technique is noticeably absent from standard educational reviews of quantitative syntheses. The Encyclopedia of Educational Research (1982) simply references the Hunter-Schmidt technique as an application of meta-analysis to personnel psychology (Smith, 1982). In the Handbook of Research on Teaching (1986), H.J. Walberg, in his chapter entitled "Synthesis of Research on Teaching", does not mention the Hunter-Schmidt method. This chapter addresses which techniques have been used in the field of education, not which techniques are available; therefore, it can be concluded that the Hunter-Schmidt technique is not commonly used in the field of education. In the same volume, Robert Linn, in his chapter entitled "Quantitative Methods", describes the Hunter-Schmidt technique and concludes, "The meta-analysis techniques advocated by Schmidt and Hunter have had a profound effect on the interpretation of validity study results in personnel psychology. The approach has applicability in many other areas of research, including research on teaching" (Linn, 1986, p. 115).

Glass Technique vs. Hunter-Schmidt Technique

The Glass technique and the Hunter-Schmidt technique are similar in many ways but they differ in several key ways. They are similar in that they both recommend using every available study, published or unpublished, in a meta-analysis (Glass, McGaw, and Smith, 1981; Hunter and Schmidt, 1990). However, they differ in three specific areas: effect size formula, correction for sampling error, and correction for measurement error in the dependent variable. A brief discussion of the Glass and Hunter-

Schmidt techniques for each of these areas follows.

Effect Size Both the Glass and the Hunter-Schmidt techniques calculate an effect size. The effect size measures the average performance of the experimental group in relation to the control group. The effect size is calculated by subtracting

$$ES = \frac{\bar{X}_e - \bar{X}_c}{sd}$$

the mean of the control group from the mean of the experimental group, and this difference is divided by the standard deviation. Glass (1976) disagrees with Hunter and Schmidt (1990) over which standard deviation should be used in the effect size formula. Glass proposes using the control group standard deviation because it is unaffected by the treatment (Glass, McGaw, and Smith, 1981). Hunter and Schmidt, on the other hand, propose using the pooled within group standard deviation because it has only half the error of the control group standard deviation (Hunter and Schmidt, 1990). In both the Hunter-Schmidt and Glass techniques, all effect sizes within each study can be averaged to form a study effect size. The study effect sizes are then averaged to form the overall mean effect size for the meta-analysis (Glass, McGaw, and Smith, 1981; Bangert-Drowns, Kulik, and Kulik, 1983; Wortman and Bryant, 1985; Hunter and Schmidt, 1990). It is the overall mean effect size which is published as representing the size of the effect.

Correction for Sampling Error In addition to calculating an effect size, Hunter and Schmidt recommend testing the variance of

$$\frac{e}{VARIANCE} = .75$$

the overall mean effect size for sampling error. This is accomplished by calculating the overall mean effect size error variance and dividing it by the variance of the overall mean effect size. The hypothesis tests whether or not the ratio of the error variance to the variance is .75 or greater. If 75% of the variance is error variance, then it is assumed that the rest of the variation between study effect sizes is due to other types of error (Hunter and Schmidt,1990).

If, however, the ratio is less than .75, then further analysis is recommended by Hunter and Schmidt (1990) to determine if there are any variables within the studies that are causing the effect sizes to differ significantly from each other. These variables are called "moderator" variables. Examples of study variables (that might become moderator variables) include study identification variables (e.g., year of publication, and whether it was a journal article, dissertation, or ERIC document), sample variables (e.g., size, gender, race, SES, grade, achievement level, number of classes), dependent measure variables (e.g., instrument type, subject area, time of measurement, validity, and reliability), design characteristics (e.g., design, threats to validity, selection process), and treatment characteristics (e.g., length of treatment, verification of treatment delivery, control group activity, method of instruction).

Hunter and Schmidt recommend using Pearson correlations to determine the strength of relationship between the study effect sizes and various study characteristics that are hypothesized to be moderator variables (Hunter and Schmidt, 1990). Glass recommends using Pearson correlations, ANOVAs, or regression analysis to locate moderator variables but does not recommend testing for sampling error (Glass, McGaw, and Smith, 1981). He simply assumes something other than sampling error is causing the variation among study effect sizes, and routinely runs correlations to determine which variables are impacting the overall mean effect size.

<u>Correction for Measurement Error</u> Hunter and Schmidt (1990) believe that measurement error can affect the overall mean effect size. They state that measurement error inflates the standard deviation (which is the denominator of the effect size equation) and thus lowers the value of the effect size. To correct the deflated effect size, they recommend dividing the effect size by the square root of the reliability coefficient of the dependent variable measure. This correction should increase

$$\frac{ES}{\sqrt{r_{xx}}}$$

the value of the effect size. Hunter and Schmidt (1990) maintain that since meta-analyses are sometimes compared to each other, it is important not to underestimate the size of the effect (p. 303). This is especially true in the case where the overall mean effect size is not significantly different from zero, but when corrected for measurement error, becomes significant. Glass does not include any correction formulas for measurement error.

Purpose

No direct comparison has been made of the Glass meta-analytic technique and the Hunter-Schmidt meta-analytic technique. The purpose of this study was to compare the application of these two techniques on three meta-analytic studies from the education literature. One research question and four hypotheses were formulated for this study. They are listed as follows:

Research Question: How does the Hunter-Schmidt meta-analytic technique differ from the Glass meta-analytic technique when applied to a data set of experimental studies from the education literature?

Hypothesis #1: The overall mean effect size will be larger in a Hunter-Schmidt meta-analysis than in a Glass meta-analysis due to the correction for measurement error (.05 alpha level, one tailed test) when compared on the same data set of experimental studies.

Hypothesis #2: The overall mean effect size calculated using the pooled within group standard deviation in a Hunter-Schmidt meta-analysis will not differ significantly from that in a Glass meta-analysis which uses the control group standard deviation ($p < .05$ two tailed test). No correction for measurement error accompanies this analysis. (If they do not differ significantly, then any differences between the two overall mean effect sizes after correcting for measurement error can be explained by the measurement error correction.)

Hypothesis #3: Most (75%) of the variation between study effect sizes will be due to sampling error according to sampling error correction formulas from the Hunter-Schmidt meta-analytic method.

Hypothesis #4: No moderator variables will be found because most (75%) of the variation between study effect sizes is due to sampling error.

Method

Sample

The following criteria were established before choosing the meta-analytic data sets for this study. First, the authors of each of the three data sets had to state that they used the Glass technique and Glass formulas. Second, the meta-analytic studies had to use experimental and control group data so that they fit the formulas for experimental group meta-analyses rather than correlational meta-analyses. Third, the content of the three meta-analytic data sets had to be in differing areas of the cognitive domain but still within the field of education.

To insure generalizability, two criteria were applied. First, the meta-analyses had to span elementary through high school students so that the populations represented were not of an overly limited nature. Second, the three meta-analytic data sets had to vary in their overall effect sizes. This criterion was applied because the Hunter-Schmidt formulas were hypothesized to raise the overall effect size and it was not known whether the formulas would impact a large effect size in the same way as they would impact a small effect size.

Glass et al. (1981) indicated that one way to compare effect sizes was to look at effect sizes on similar studies in similar domains. The three meta-analyses chosen for this study were in the domain of metacognition, and dealt with the effect of cognitive intervention on student achievement. The first meta-analytic study was conducted by Samson, Strykowski, Weinstein, and Walberg (1987) and was entitled "The Effects of Teacher Questioning Levels on Student Achievement: A Quantitative Synthesis". The second meta-analysis used in this study was conducted by Haller, Child, and Walberg (1988) and was entitled "Can Comprehension Be Taught? A Quantitative Synthesis of 'Metacognitive' Studies". The third meta-analytic data set chosen for this study was conducted by Gordon E. Samson (1985) and was entitled "Effects of Training in Test-Taking Skills on Achievement Performance: A Quantitative Synthesis".

Procedures

A list of the individual studies used in each of the three meta-analyses was obtained from the first author. A copy of each of the journal articles, dissertations, and ERIC documents included in each of the three meta-analyses was obtained, and relevant statistical data were collated. These statistical data included means and standard deviations from the treatment and control groups, sample size of each study, and a reliability estimate from any instrument used in the study to measure the dependent variable.

The author of this study defined each of the meta-analyses as the immediate effect of a treatment on achievement. Thus, it was not appropriate to use delay scores, aptitude scores, or formative evaluation measures. These exclusions accounted for 21% of all dependent variable effect sizes, but no studies were excluded in that there was at least one relevant dependent variable effect size in each study.

An attempt was made to obtain reliability coefficients for all instruments used in each study from each of the meta-analyses. If the reliability coefficient was not published in the study, it was obtained from the test manual if available. In two studies, the reliability coefficient was not reported in the study and the test manual was not available. In these two cases, other studies within the same meta-analysis that used the same instrument on similar populations were consulted for the reliability coefficient, and that coefficient was used. Reliability coefficients were available for eighty-five percent of the studies. Hunter and Schmidt (1990) recommended averaging the available reliability coefficients for each data set and adjusting the overall effect size by the average reliability coefficient. The average reliability coefficient was used in this study.

The authors of the three meta-analyses were contacted for coding information, i.e., how each individual study was coded within the meta-analysis so that the meta-analysis could be replicated using the same coding information for the Hunter-

Schmidt formulas. The authors did not respond, but enough coding information was available in the three data sets for the author of this study to replicate the coding information.

A coding sheet was devised which included categories used by the authors of each of the three meta-analytic studies. The categories included study identification characteristics (e.g., source and year of publication), sample characteristics (e.g., sample size, gender, race, SES, achievement level, number of classes), dependent measure characteristics (e.g., instrument type, subject area, time of measurement, validity, and reliability information), design characteristics (e.g., design, selection process, internal and external threats to validity), and treatment characteristics (e.g., length of treatment, method of instruction, verification of treatment, control group activity). Each study within each meta-analysis was coded using the categories stated by the author.

Statistical Analyses

A correlated t-test was used to compare the overall mean effect sizes that were calculated using the Glass and Hunter-Schmidt technique. A search for moderator variables was conducted by running two sets of analyses: (1) Pearson correlations were run to determine the strength of relationship between coded variables on continuous data and study effect sizes ($p < .01$), and (2) ANOVAs were run to determine the impact of coded variables for categorical data on study effect sizes ($p < .01$). Where possible, data were split into equal cell sizes for the oneway ANOVA procedures on categorical data. All data were analyzed using the SPSSX statistical package (SPSS Inc., 1988).

Results

All studies within each of the three meta-analyses were well designed according to standards set up by Campbell and Stanley (1963). The experimenters in all the studies randomly assigned students to the treatment and control groups, and used either a post-test only control group design or a pretest post-test control group design.

Each of the three meta-analyses were recalculated using the Glass technique and the Hunter-Schmidt technique. A brief description of each meta-analysis is presented along with the results of the meta-analytic calculations. In all three meta-analyses, the overall mean effect size was significantly different from zero whether the Glass technique or the Hunter-Schmidt technique was used. No moderator variables were found in any of the three meta-analyses even though the Hunter-Schmidt sampling error formulas indicated something other than sampling error was accounting for the variation among effect sizes.

Teacher Questioning (Samson et al. 1987) Samson et al. (1987) conducted a meta-analysis of the effect of teacher questioning on student achievement. Their meta-analysis consisted of 14 studies (see Table 1) examining whether a treatment group receiving "high level" questions in class discussions tested higher on various achievement measures than a control group receiving "low level" questions. High and low level questions were defined according to Bloom's taxonomy (1956), where high level questions consisted of application, analysis, synthesis, and evaluation type questions, and low level questions consisted of knowledge and comprehension level questions.

Samson et al. (1987) reported a Glass overall mean effect size of .26. The author of this study obtained a .29 Glass overall mean effect size when replicating the study because inclusion criteria were slightly different. Achievement scores that were administered immediately after treatment were included in this study. No effect sizes derived from delayed testing or aptitude measures were included in the calculations. It appears that Samson et al. (1987) included delayed test scores and aptitude measures.

The overall mean effect size using the Glass method was .29, and the uncorrected Hunter-Schmidt overall mean effect size was .30 (see Table 2). There was no significant difference between these two, indicating that the use of the pooled within group standard deviation did not significantly change the overall mean effect size. The overall mean effect size (corrected for measurement error) using the Hunter-Schmidt method was .34. The corrected overall mean effect sizes from the Hunter-Schmidt meta-analytic method (.34) and Glass meta-analytic method (.29) were not significantly different from each other at the .05 level.

Table 1

Summary of Number of Studies, Number of Participants, Published and Calculated Overall Mean Effect Sizes, Medians, Percentage of Variance Attributed to Sampling Error, and Average Reliability Coefficients of Each Meta-analysis Used In This Study

	Teacher Questioning (Samson et al.) 1987	Testwiseness (Samson) 1985	Reading Comprehension (Haller et al.) 1988
Number Studies	14	23	20
Number Participants	2,865	5,584	1,408
Average Reliability Coefficient	.75	.90	.90
% Variance Attributed to Sampling Error	7%	34%	38%
Published Effect Size and standard deviation	.26 (.32)	.33 (.19)	.71 (.81)
Glass Mean and sd:	.29 (.56)	.34 (.29)	.75 (.65)
Hunter-Schmidt Mean and sd:	.34 (.68)	.36 (.31)	.83 (.60)
Glass Median ES:	.15	.35	.79
Hunter-Schmidt Median ES:	.17	.34	.86

Table 2

T-test Comparing Study Weighted Overall Mean Effect Sizes Calculated Using Glass's Meta-analytic Method and Hunter-Schmidt's Meta-analytic Method on All Meta-analytic Data Sets Recalculated For This Study

Method	Mean	SD	t	p
Teacher Questioning (N=14 studies)				
Glass	.29	.56		
Hunter-Schmidt (uncorrected)	.30	.59	.40	.396
Hunter-Schmidt	.34	.68	1.24	.119
Testwiseness (N=23 studies)				
Glass	.34	.29		
Hunter-Schmidt (uncorrected)	.34	.29	.00	1.000
Hunter-Schmidt	.36	.31	2.41*	.013
Reading Comprehension (N=20 studies)				
Glass	.75	.65		
Hunter-Schmidt (uncorrected)	.79	.56	1.10	.140
Hunter-Schmidt	.83	.60	2.69**	.007

*$p<.05$
**$p<.01$

The Hunter-Schmidt formulas for sampling error were applied, and it was found that only 7% of the overall variance of the mean effect sizes was due to sampling error, which is much less than the 75% hypothesized. Pearson correlations for continuous variables between study characteristics and study effect sizes were run to determine which variables accounted for the variation among effect sizes. No significant correlations were found at the .01 alpha level. ANOVAs were also performed on the study effect sizes and coded variables, and again, no significant differences were found at the .01 level.

Meta-analysis of Testwiseness (Samson, 1985) Samson (1985) conducted a meta-analysis of the effect of testwiseness training on student achievement. His meta-analysis consisted of 23 studies (see Table 1) which examined whether a treatment group receiving training in test-taking skills tested higher on various achievement measures than a control group receiving no training. Samson used Millman, Bishop, and Ebel's (1965) taxonomy to define the elements within the domain of testwiseness. Briefly, testwiseness is defined as "a subject's capacity to utilize the characteristics and formats of the test and/or test-taking situation to receive a high score" (Millman, Bishop, and Ebel, 1965).

Samson (1985) reported a Glass overall mean effect size of .33. The author of this study obtained a .34 Glass overall mean effect size when replicating the study because inclusion criteria were slightly different. Achievement scores that were administered immediately after treatment were included in this study. No effect sizes derived from delayed testing or aptitude measures were included in the calculations. It appears that Samson (1985) included delayed test scores and aptitude measures.

The overall mean effect size using the Glass method was .34, and the uncorrected Hunter-Schmidt overall mean effect size was also .34 (see Table 2). There was no significant difference between these two, indicating that the use of the pooled within group standard deviation did not significantly change the overall mean effect size. The overall mean effect size (corrected for measurement error) using the Hunter-Schmidt method was .36. The corrected overall mean effect sizes from the Hunter-Schmidt meta-analytic method (.36) and Glass meta-analytic method (.34) were significantly different from each other at the .05 level.

The Hunter-Schmidt formulas for sampling error were applied, and it was found that only 34% of the overall variance of the mean effect sizes was due to sampling error. No moderator variables were found in the correlation and ANOVA analyses.

Reading Comprehension (Haller et al. 1988) Haller et al. (1988) conducted a meta-analysis of the effect of metacognitive training on reading comprehension achievement. Their meta-analysis consisted of twenty studies which examined whether a treatment group receiving training in the use of metacognitive strategies tested higher on various achievement measures than a control group receiving traditional reading instruction. The authors used Flavell's definition of metacognition which includes the awareness, monitoring, and regulating of one's cognitive processes (Flavell, 1971). All treatments used in this meta-analysis represented some type of application of awareness strategies, monitoring strategies, and regulating strategies.

Haller et al. (1988) reported an overall mean effect size of .71. The author of this study obtained a .75 Glass overall mean effect size when replicating the study because inclusion criteria were slightly different. Achievement scores that were administered immediately after treatment were included in this study. No effect sizes derived from delayed testing, aptitude measures or formative evaluation measures were included in the calculations. It appears that Haller et al. (1988) included delayed test scores and aptitude measures.

The overall mean effect size using the Glass method was .75, and the uncorrected Hunter-Schmidt overall mean effect size was .79 (see Table 2). There was no significant difference between these two, indicating that the use of the pooled within group standard deviation did not significantly change the overall mean effect size. The overall mean effect size (corrected for measurement error) using the Hunter-Schmidt method was .83. The corrected overall mean effect sizes from the Hunter-Schmidt meta-analytic method (.83) and Glass meta-analytic method (.75) were significantly different from each other at the .01 level.

The Hunter-Schmidt formulas for sampling error were applied, and it was found that only 38% of the overall variance of the mean effect sizes was due to sampling error. Since this was less than 75% of the overall variance, a search for moderator variables was conducted. No moderator variables were found in either the correlation analyses or the ANOVAs.

Conclusions/Implications

The results of this study indicate that the correction for measurement error in the Hunter-Schmidt method significantly affected the overall mean effect size, thus the first hypothesis of this study was supported. Samson (1985) and Haller et al. (1988) had significantly higher Hunter-Schmidt overall mean effect sizes than Glass overall mean effect sizes. Samson et al. (1987) probably did not reach significance because of the small number of studies (N = 14), and the fact that there was a large variation among the fourteen study effect sizes. Also, the median effect size was half the overall mean effect size, indicating a skewed distribution.

Hypothesis #2 stated that there would be no significant difference between the uncorrected Hunter-Schmidt overall mean effect size and the Glass overall mean effect size. This hypothesis was supported in all three meta-analyses, indicating that it makes no difference whether the control group or pooled within group standard deviation was used. This means that the difference in the Glass and Hunter-Schmidt (corrected for measurement error) overall mean effect sizes is due to the correction for measurement error, and is not significantly influenced by the use of the pooled within group standard deviation. It was the correction for measurement error that caused the two overall mean effect sizes to be significantly different from each other.

Hypothesis #3 stated that most (75%) of the variation among effect sizes was due to sampling error. This hypothesis was rejected in all three meta-analyses. Even though the sampling error formula indicated a search for moderator variables was needed, no moderator variables were found; so hypothesis #4 was also rejected.

The question of how practical it is to use the Hunter-Schmidt technique must be addressed. The reliability coefficients were published in only half of the research studies included in the three meta-analytic data sets. Thus, many reliability coefficients had to be obtained from test manuals or other studies using the same instruments. This was a time consuming procedure, and the reliability coefficients were not always readily available.

Also, the practical difference between a .34 overall mean effect size and a .36 overall mean effect size is minimal, even though they are significantly different from each other. They both are significantly different from zero, and they both represent a similar percentile rank within a normal distribution (see Table 3). An effect size of .36 represents .36 of one standard deviation which is the same as a percentile rank of 64. An effect size of .34 represents .34 of one standard deviation which is the same as a percentile rank of 63. In the above example, students who are given testwiseness strategies will score at the 63rd or 64th percentile rank on various achievement measures in comparison to a control group whose members will score at the 50th percentile. If the meta-analysis was conducted using the Glass method, students would be measured as scoring at the 63rd percentile rank in comparison to a control group of students. If the meta-analysis was conducted using the Hunter-Schmidt method, students would be measured as scoring at the 64th percentile rank in comparison to a control group of students. As can be seen in this example, it can be argued that the Hunter-Schmidt correction formulas are technically more accurate, but from a practical standpoint, the Glass formulas appear to give an adequate picture of the size of the effect and are more easily calculated.

Limitation

Hunter and Schmidt (1990) recommend the use of the study effect size in the meta-analysis calculations. In order to tightly control this study, the study effect size was also used in the Glass calculations. The use of the study effect size created a limitation in this study because all of the meta-analyses had a relatively small number of studies, thus making it difficult to find significance in the correlations and ANOVA's when searching for moderator variables.

Table 3

Effect Sizes and Equivalent Normalized Percentile Ranks of Samson et al. (1987), Samson (1985), and Haller et al. (1988) Using the Glass Meta-Analytic Method, the Hunter-Schmidt Meta-Analytic Method With No Measuremet Error Correction, and the Hunter-Schmidt Meta-Analytic Method With Measurement Error Correction.

	Effect Size	Percentile Rank
Samson et al. (1987)		
Glass	.29	61
Hunter-Schmidt (uncorrected)	.30	62
Hunter-Scmidt	.34	63
Samson (1985)		
Glass	.34	63
Hunter-Schmidt (uncorrected)	.34	63
Hunter-Schmidt	.36	64
Haller et al. (1988)		
Glass	.75	77
Hunter-Schmidt (uncorrected)	.79	79
Hunter-Schmidt	.83	80

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