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ABSTRACT

This paper presents a testing procedure that incorporates three key elements. The first element is the use of non-nil null hypotheses. The second element is the determination of a practically significant level that is incorporated into the corresponding non-nil null hypothesis. The third element is the use of a randomization test to statistically test each non-nil null hypothesis. This procedure stresses two philosophical positions. First, the concepts of practical and statistical significance are both essential components in the evaluation process. Second, the use of this procedure encourages the researchers to consider the process of establishing the level of practical significance, not only as a statistical one, but also, as one in which the researchers would consider societal concerns and cost versus benefit comparisons. An appendix contains the computer program for the randomization test. (Contains 38 references.) (Author/SLD)

Running head: TESTING FOR STATISTICAL AND PRACTICAL SIGNIFICANCE

Testing for Statistical and Practical Significance: A Suggested Technique Using a Randomization Test

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Paper presented at the annual meeting of the

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Abstract

This paper presents a testing procedure that incorporates three key elements. The first element is the use of non-nil null hypotheses. The second element is the determination of a practically significant level which is incorporated into the corresponding non-nil null hypothesis. The third element is the use of a randomization test to statistically test each non-nil null hypothesis. This procedure stresses two philosophical positions. First, the concepts of practical and statistical significance are both essential components in the evaluation process. Second, the use of this procedure encourages the researchers to consider the process of establishing the level of practical significance, not only as a statistical one, but also, as one in which the researchers would consider societal concerns and cost versus benefit comparisons.

Testing for Statistical and Practical Significance:

A Suggested Technique Using a Randomization Test

We believe that current research practices will be strengthened if researchers incorporate into their work the use of nil-null hypotheses that are based on effect sizes deemed important by researchers and practitioners. Thus, we are proposing that researchers consider using a testing procedure that incorporates three key elements. The first element is the use of a non-nil null hypothesis, i.e., a null hypothesis in which the test value is not zero but rather some value of importance or interest to the researchers. The second element is the determination of a practically significant level which is incorporated into the non-nil null hypothesis. The third element is the use of a randomization test to statistically test the non-nil null hypothesis.

This procedure stresses two of our philosophical positions. First, the concepts of practical and statistical significance are both essential components in the evaluation process. Second, the use of this procedure encourages the researchers to consider the process of establishing the level of practical significance, not only as a statistical one, but also, as one in which the researchers would consider societal concerns and cost versus benefit comparisons.

Null Hypothesis Statistical Testing

As noted by Kirk (1996), "for almost 70 years, null hypothesis significance testing has been an integral part of the research enterprise in which behavioral and educational researchers engage. And for almost 70 years, null hypothesis significance testing has been surrounded by controversy" (p. 746). Berkson published an article in 1938 that provided one of the earliest challenges to the use of null hypothesis statistical testing. More recently, numerous authors have challenged the use of null hypothesis statistical testing (Carver, 1978, 1993; Cohen, 1990, 1994;

Falk, 1986; Falk & Greenbaum, 1995; Huberty, 1987, 1993; Meehl, 1967; Rozeboom, 1960; Shaver, 1980, 1993; Thompson, 1989a, 1989b, 1996, 1997, 1998, 1999a, 1999b, 1999c). Other authors, however, have defended its use (Cortina & Dunlap, 1997; Frick, 1996, 1999; Hagen, 1997; Levin, 1993, 1996, 1998; Levin and Robinson, 2000; Robinson & Levin, 1997).

Thompson (1999a) stated: "A few scholars have called for the banning of statistical significance tests. However, the fact that many psychologists misinterpret statistical significance tests is not a reasonable warrant for banning these tests. Consequently, attention has now turned toward ways to improve practice" (p.169). We concur with the view expressed by Thompson. Thus, the analytic technique we are recommending is based on various suggested changes in current research practices.

Recommended Changes in Current Research Practices

Various researchers have suggested ways to improve or supplement current research practices. We believe that three of the recommended changes are noteworthy. First, as suggested by numerous authors, including Cohen (1988, 1994), Huberty (1993), Robinson and Levin (1997), Shaver (1993), Thompson (1996, 1999a, 1999b, 1999c, 2000), current research practice should incorporate the reporting and interpreting of the effect sizes, i.e., measures of practical significance. Second, as argued by Robinson and Levin (1997), the results of statistical hypothesis testing should be conducted and reported along with the effect sizes. Third, as recommended by Cohen (1994), researchers should use non-nil null hypotheses. Cohen stated: "Even null hypothesis testing complete with power analysis can be useful if we abandon the rejection of the point nil hypotheses [nil null hypotheses]" (p. 1002).

Effect sizes versus statistical significance. Currently, the reporting of effect sizes, which is considered to be a method of addressing practical significance, is strongly supported by researchers. Such support can be found in recent suggested changes in research practices by various journals and a recommended change in the editorial policy of the American Psychological Association. As noted by Thompson (1997), the editor of Educational and Psychological Measurement: "As an editor, I do not reject articles reporting the results of statistical significance tests. However, I do expect to see effect sizes . . . reported and interpreted" (pp. 31-32). The Association for Assessment in Counseling (1990) stated the following guidelines for authors who publish in the journal Measurement and Evaluation in Counseling and Development: "7. Authors are strongly encouraged to provide readers with effect size estimates as well as statistical significance tests. . . . 8. Studies in which statistical significance is not achieved will still be seriously considered for publication" (p. 48). The change in editorial policy of the American Psychological Association is evident in its 1994 APA style manual which states: "You are encouraged to provide effect-size information" (APA, 1994, p. 18).

Importance of conducting statistical hypothesis testing. Less agreement, however, has been reached with respect to the importance of conducting statistical hypothesis testing when effect sizes are reported and interpreted. Shaver (1993) and Thompson (1999c) expressed the view that formal statistical hypothesis testing might augment the reporting of effect sizes, i.e., practical significance. Shaver expressed the view that: "In short, studies should be published without tests of statistical significance, but not without effect sizes" (p.311). Thompson echoed a similar view: "My view is that statistical significance testing is in many respects often merely

irrelevant. I don't object to statistical tests as long as effect sizes of some flavor are always reported" (p. 159).

Levin (1998), Levin and Robinson (2000), and Robinson and Levin (1997) took issue with the position taken by Shaver (1993) and Thompson (1999c). Robinson and Levin expressed the view that declarations of statistical significance should regularly precede deliberations of substantive significance. In light of this position, Robinson and Levin (1997) proposed a two-step data analysis process. In this two-step procedure the researchers would, first, determine whether the observed effect was statistically significant. Only if the observed effect was statistically significant would the researchers implement the second step, in which they would assess the practical significance of the observed effect.

Reasons for the dearth of non-nil hypotheses in current research. Thompson (1999a) expressed the view that researchers continue to use nil null hypotheses for two reasons. First, most computer packages assume the researchers are testing nil null hypotheses. Thus, they are not equipped to invoke the necessary changes in calculations. As noted by Selin and Lapsley (1985, 1993), such changes include the use of critical values obtained from noncentralized t and F distributions. Second, some of the complexities of using non-nil null hypotheses are not yet readily applicable in many designs.

In spite of these two roadblocks, a testing technique is available to researchers who believe it is important to test non-nil hypotheses. Edgington (1995) has suggested that researchers can readily employ non-nil null hypotheses if they utilize randomization testing techniques. Edgington expressed the view that: "A randomization test null hypothesis need not

be simply one of no differential treatment effect [a nil null hypothesis] . . . but can . . . [reflect] response magnitudes [a non-nil null hypotheses]" (pp. 319-320).

Acting on the Three Recommended Changes in Research Practices

Our view regarding the debate on the need and importance of considering the statistical significance of the observed effect along with its effect size, i.e., practical significance, is more closely aligned with the position taken by Levin (1998), Levin and Robinson (2000), and Robinson and Levin (1997). Thus, we believe that statistical significance of the observed effect is an essential element to evaluate along with the practical significance of the effect.

The process that we are encouraging educational researchers to use requires them to assess whether the observed effect is statistically significant. The process we are recommending, however, requires the observed effect not be statistically tested against the lack of any effect, i.e., a value of zero, but rather against a level deemed to be practically significant. Thus, we are advocating the use of non-nil null hypotheses that incorporate a value defined by the researchers as indicating practical significance. This practically significant value should be derived by the researchers in a manner based on the position articulated by Kirk (1996) who stated that it is important not to sanctify effect size numbers such as Cohen's (1988) .2, .5, and .8. Kirk suggests that if practical significance is to be a useful concept, its determination must not be ritualized. Judgment regarding what is required for practical significance should inevitably involve a variety of considerations, including societal concerns and costs versus benefit comparisons, just to mention a few. We do believe, however, that Cohen's identified effect size values, labeled as small, medium, and large, can be used by researchers and practitioners as a starting point for the identification of effect sizes that have meaning to them.

Since we are suggesting that non-nil null hypotheses should be employed, we recommend that it be statistically tested with randomizations tests. A randomization test has two desirable characteristics when used to test non-nil null hypotheses in educational and psychological settings. First, a randomization test will generate the distribution needed by the researcher to determine if the test statistic is statistically significant. Thus, the researcher would not need to incorporate special critical values as required by the use of the t and F values generated by most standardized statistical programs. Second, a random sample is not required when a randomization test is conducted. Edgington (1995) stated the position that: "A randomization test is valid for any kind of sample, regardless of how the sample is selected. This is an extremely important property because the use of nonrandom samples is common in experimentation" (p.6).

Technique

Our suggested analytic technique incorporates three major elements. First, a non-nil null hypothesis and its alternative are employed. Second, the key value contained in a given set of hypotheses is one that is deemed practical significant. Third, the non-nil null hypothesis is tested with a randomization test. As previously stated, the procedure we are recommending reflects two of our philosophical positions. First, the concepts of statistical and practical significance are both essential components of the evaluation process. Second, what is defined to be practically significant is thoughtfully determined by the researchers and practitioners. Once the value used for practical significance is established, it becomes a key value in the statistical testing procedure.

An Illustration of the Recommended Testing Procedure

We believe the best way to present our suggested testing procedure is through its application to a research question and the corresponding data. In this illustration, we are using

data collected in a study conducted by Piirto, Beach, Cassone, Rogers, and Fraas (2000). In this study, the authors were interested in determining whether high-school aged gifted students have higher intellectual scores than high-school aged non-gifted students. The intellectual scores measured the students' levels of desire for knowledge and inquiry. This illustration includes a total of 49 gifted students and 51 non-gifted students. Each intellectual score was multiplied by 100 to facilitate the presentation of this illustration.

Before the non-nil null and the alternative hypotheses were constructed, the degree of difference between the mean scores of the gifted and non-gifted students, which was deemed by the researchers and practitioners to be practically significant, had to be established. After considerable discussion and reflection, a difference in the group means that exceeded four points was deemed necessary for practical significance to be achieved. The implications of the difficulty that we encountered in arriving at this value will be presented in a later portion of this paper.

Since practical significance was equated with values in excess of four points, the non-nil null and alternative hypotheses were constructed as follows:

H_0: The mean of the gifted students does not exceed the mean of the non-gifted students by more than four points.

H_1: The mean of the gifted students does exceed the mean of the non-gifted students by more than four points.

This non-nil null hypothesis was tested with a randomization test, which was generated by a computer program entitled Resampling Stats version 4.2b2 (Resampling Stats, 1999). The specific program used to conduct this randomization test is listed in Appendix A.

Before the students scores were subjected to the randomization test, the value of four was subtracted from each gifted student's score. The mean of the gifted students in the sample was 23.63. And, of course, the mean of the gifted students' modified scores was 19.63. The standard deviation of gifted students' modified scores was 16.20, which, of course, matched the standard deviation of their non-modified scores. The mean and standard deviation values for the non-gifted students were 15.78 and 14.74, respectively.

Once the scores of the gifted students and the non-gifted students were entered into the randomization test program, it generated a distribution of 10,000 differences between the mean of the students randomly assigned to the gifted group and the mean of the students randomly assigned to the non-gifted group. The distribution generated by the program is contained in Appendix B. The program calculated the proportion of the 10,000 values in the distribution that exceeded the difference between the mean of the gifted students' modified scores ($\bar{x} = 19.63$) and the mean of the non-gifted students' scores ($\bar{x} = 15.78$). This proportion, which was .107, was compared to an established maximum proportion of values in the distribution that we were willing to obtain and still reject the non-nil null hypothesis. We established this maximum proportion to be .05. Since the calculated proportion of .107 exceeds the established maximum proportion of .05, we were not willing to reject the non-nil null hypothesis. Thus, we concluded that any difference between the means of the gifted students and the non-gifted students in excess of four points, is more likely to occur by chance at a level greater than we were willing to accept.

Difficulty in Establishing the Value for Practical Significance

Implementing this procedure revealed to us that establishing the level beyond which researchers and practitioners would consider the difference to be practically significant is not a

simple task or one with which researchers and practitioners have had a great deal of experience. In this application we found ourselves falling back on Cohen's low, medium, and high guidelines. It became obvious to us that this task is qualitative in nature and the reliance on Cohen's guidelines is not the best manner to accomplish this task. In regards to this point we are in agreement with Kirk (1996) who stated:

> With respect to determining the practical significance of results, Cohen's definitions of small, medium, and large effects represent a good beginning. However, much more systematic research is needed to extend his work. . . . If practical significance is to be a useful concept, its determination must not be ritualized. (p. 756)

The development of procedures and thought processes that could assist researchers and practitioners with the task of identifying practical significant levels may prove very beneficial to the field of research methodology.

Summary

In this paper we have proposed a hypothesis testing technique that utilizes a non-nil null hypothesis in which the key value is set by the researchers and practitioners at a level deemed necessary for practical significance to be reached. Once the non-nil null hypothesis is constructed, it is tested by means of a randomization test. This technique stresses two of our philosophical positions. First, the concepts of practical and statistical significance are both essential components in the evaluation process. Second, the use of this procedure encourages the researchers to consider the process of establishing the level of practical significance, not only as a statistical one, but also, as one based on societal concerns and cost versus benefit comparisons.

During the process of implementing this testing procedure we discovered two areas in which further study and reflection may prove fruitful. First, we discovered that the most difficult task was establishing the level of practical significance. We found ourselves relying to a significant extent on Cohen's effect size guidelines. We believe that further developments in the methods used to identify practical levels of significance would be very beneficial to today's researchers. Second, the ease by which researchers and practitioners can use this method is an important issue. One such question we believe is important to address regarding this issue of ease of application is: How can the current major statistical computer software packages be used in conjunction with this procedure, specifically the testing of non-nil null hypotheses? This question is critical to investigate due to the likelihood that unless researchers are able to test non-nil null hypotheses with readily available computer software, they may continue to exclusively use nil null hypotheses.

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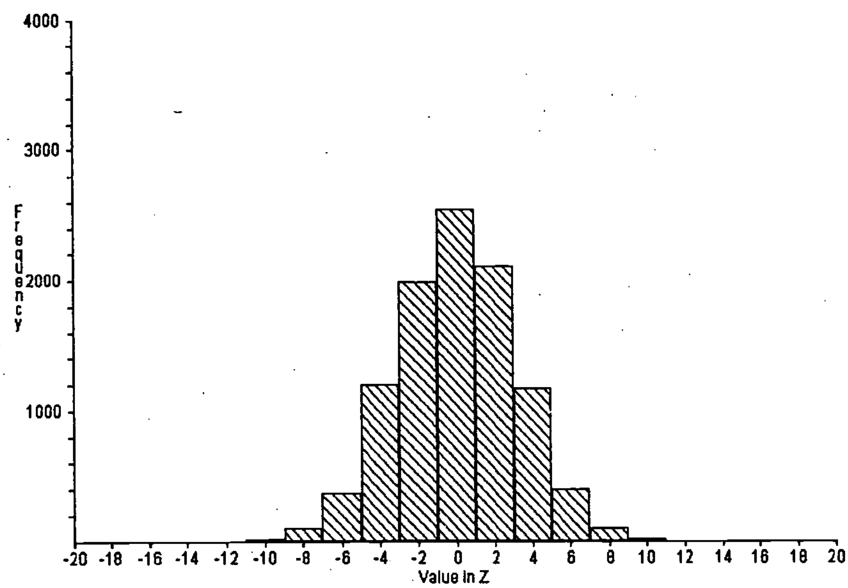
Appendix A

Computer Program for the Randomization Test

```
add 10000 0 rep
maxsize default 10000
read file "data effect tab" group gender  ntanew
count group=0 groupg  'Number of observations in Group0'
count group=1 groupv  'Number of observations in Group1'
print groupg groupv
add groupg+1 minv
add groupg groupv maxv
print minv maxv
tagsort group key
take ntanew key value$
sort group group$
take value$ 1,groupg g  'these numbers will depend on the number of observations in the gifted
group'
take value$ minv,maxv v 'these numbers will depend on the number of observations in the
vocational group'
mean g meang
mean v meanv
stdev g SDg
stdev v SDv
subtract meang meanv diff
print meang SDg meanv SDv diff
repeat rep
        shuffle ntanew all$
        take all$ 1,groupg gifted$
        take all$ minv,maxv voc$
        mean gifted$ meang$
        mean voc$ meanv$
        subtract meang$ meanv$ diff$
        score diff$ z
end
count z >= diff k
divide k rep propor
print  propor
histogram z
```

Appendix B

The Distribution of 10,000 Difference Values



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