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ABSTRACT

The terms "causal-comparative" and "correlational" are dated and misleading and suggest a false dichotomy in research. Textbook authors should stop misleading educational research students and researchers in training with the notion that causal-comparative research provides better evidence for causality than correlational research. They should focus on more important issues surrounding causality and how to design relatively strong nonexperimental designs. Because of the importance of nonexperimental research in education, it is essential that students learn how to develop defensible nonexperimental research studies. This will involve making meaningful distinctions among different forms of nonexperimental research and designing studies to meet the intended research purpose. (Contains 32 references.) (SLD)

Running head: IT'S (BEYOND) TIME TO DROP THE TERMS

It's (Beyond) Time to Drop the Terms

Causal-Comparative and Correlational Research

in Educational Research Methods Textbooks

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What is the Issue?

Authors of popular educational research methods books make a distinction between two nonexperimental methods called causal-comparative research and correlational research (e.g., Charles, 1995; Fraenkel & Wallen, 1996; Gay, 1996; Martella, Nelson, & Marchand-Martella, 1999). According to these authors, a distinction between these two methods is that causal-comparative includes a categorical independent and/or dependent variable (hence the word "comparative" implying a group comparison) and correlational only includes quantitative variables. These authors also suggest that causal-comparative research provides better evidence of cause and effect relationships than correlational research. The following quotes from Gay's (1996) popular text demonstrate these points:

> Like correlational research, causal-comparative research is sometimes treated as a type of descriptive research since it too describes conditions that already exist. Causal-comparative research, however, also attempts to determine reasons, or causes, for the current status of the phenomena under study. (P.321) **Causal-comparative studies attempt to establish cause-effect relationships, correlational studies do not**. (P.322) Correlational research attempts to determine whether, and to what degree, a relationship exists between two or more **quantifiable variables**. (P.15) Causal-comparative and experimental research...both attempt to establish cause-effect relationships; both involve **group comparisons**. (P.16) In correlational research...each variable must be expressible in numerical form, that is, must be quantifiable. (P.318) The purpose of a correlational study may be to determine relationships between variables, or to use relationships in making predictions...Variables that are highly related [in correlational research] may **suggest causal-comparative** or experimental studies to determine if the relationships are causal. (p.296) (emphasis added)

Charles (1998) says, "Causal-comparative research **strongly** suggests cause and effect..." (p.305) but that correlational research may sometimes be used to "examine the **possible** existence of causation" (emphasis added) (p.260). In one of the newer educational research methods books on the market, Martella, Nelson, and Marchand-Martella (1999) contend that "**correlational research has a lower constraint level than causal-comparative research**. There is not an active attempt to determine the effects of the independent variable in any direct way." (emphasis added) (p.20)

The next quote is from Fraenkel, the first author of the leading selling educational research text (Fraenkel and Wallen, 1996). Fraenkel appears to agree with Gay and the others quoted above.[1] In the following message (available on the AERA Division-D archives, February 11, 1998), Fraenkel answers the question, "Why do educational researchers ... seem to believe that evidence for cause and effect will be any stronger in causal-comparative research than in correlational research?"

> Causal-comparative research involves comparing (thus the "comparative" aspect) two groups in order to explain existing differences between them on some variable or variables of interest. The only difference between causal-comparative and experimental research is that the groups being compared in causal-comparative research have already been formed, and any treatment (if there was a treatment) has already been applied. Of necessity, the researcher must examine the records of the two groups to see if he or she can offer a reasonable explanation (i.e., what "caused") the existing differences between the two groups...Correlational research, on the other hand, does not look at differences between groups. Rather, it looks for relationships within a single group. This is a big difference...one is only entitled to conclude that a relationship of some sort exists, not that variable A caused some variation in variable B...In sum, **causal-comparative research does allow one to make reasonable inferences about causation; correlational research does not.** (emphasis added)

Based on the above quotations, it should not be surprising that almost 80 percent (n=330) of the participants in an Allyn and Bacon (Fall, 1996) survey of teachers of educational research said that the distinction between causal-comparative research and correlation research should be retained.

If the only distinction, in design, between a causal-comparative and a correlational study is the scaling of the independent variable, then, the obvious question is "Why can one supposedly make a superior causal attribution from a causal-comparative study?" The answer is that the contention is completely without basis. Fraenkel's point that one approach compares groups but the other only looks at one group has nothing to do with establishing evidence of causality using nonexperimental research.

To illustrate the point, consider the following example. Suppose one is interested in learning whether two variables, time spent studying per day and test scores, are associated. If time spent studying is measured in minutes per day, then a correlational study results. If, however, time is artificially dichotomized into two groups--10 minutes or less per day and more than 10 minutes per day--a causal-comparative study results. The only true distinction between these two studies is the scaling of the variables. This is a trivial distinction and does not warrant the claim that the causal-comparative study will produce more meaningful evidence of causality. For another example, there is no reason to believe a stronger causal attribution can be made from a study measuring the relationship between gender and test grades (a causal-comparative study) than from a study measuring the relationship between time spent studying for a test and test grades (a correlational study). Both studies would be extremely weak because only a relationship between two variables, with no controls, would have been demonstrated.

The first contention of this paper is that, ceteris paribus, causal-comparative research is neither better nor worse in establishing evidence of causality than correlational research. When you compare apples to apples (e.g., the simple cases of causal-comparative and correlational research which are studies with only two variables and no controls) and oranges to oranges (e.g., the more advanced cases where similar controls are included), one cannot conclude that causal-comparative research is any better than correlational research for making causal attributions. It is essential that teachers and students of educational research understand that what is always important when attempting to make causal attributions is the examination and elimination of plausible rival explanations (Cook & Campbell, 1979; Huck & Sandler, 1979; Johnson & Christensen, 2000; Yin, 2000). The second contention of this paper is that the terms causal-comparative and correlational research are outdated and should be replaced by more current terminology. Suggestions for a new terminology are given below.

Similarities and Differences Between Causal-Comparative and Correlational Research Methods

Causal-comparative and correlation methods (as defined in educational research textbooks) both are nonexperimental methods because they lack manipulation of an independent variable. As a result, neither can provide as strong of evidence for causality as can a study based on a randomized experiment or a strong quasi-experimental design (such as the regression discontinuity design and the time series design). Indeed, even the more sophisticated theory testing approaches relying on structural equation modeling (that are commonly used in nonexperimental research, especially in correlational research) provide relatively weak evidence of causality, compared to the evidence obtained through the use of randomized experiments.

Causal-comparative and correlational studies differ on the scaling of the independent and/or dependent variables. According to popular textbooks, causal-comparative studies include at least one categorical variable and correlational studies include quantitative variables. Some categorical independent variables that cannot be manipulated and could be used in a causal-comparative study are gender, parenting style, student learning style, ethnicity, retention in grade, drug or tobacco use, and any personality variable that is operationalized as a categorical variable (extrovert versus introvert). Some quantitative independent variables that cannot be manipulated and could be used in a correlational study are intelligence, aptitude, age, GPA, and any personality trait that is operationalized as a quantitative variable (e.g., degree of extroversion). Again, the key characteristic of the independent variables in causal-comparative and correlational studies is that they either cannot be manipulated or they were not manipulated.

Both causal-comparative and correlational studies examine relationships among variables. The data from both of these approaches are typically analyzed using the general linear model (GLM), and it well known that all special cases of the GLM are correlational (e.g., Kerlinger, 1986; Tatasouka, 1993; Thompson, 1998) where the relations between variables are modeled. Given this, it is misleading to suggest, as is commonly done in educational research texts, that only correlational research examines relationships.

There is no important distinction between causal-comparative and correlational studies in terms of the techniques available for controlling confounding variables. For example, one can statistically control for confounding variables in both approaches by collecting data on the key extraneous variables and including those variables in the GLM. Likewise, one can eliminate the relationship between selected confounding and independent variables (regardless of their scaling) using matching/quota sampling approaches. Today, statistical control is usually preferred over individual matching (Rossi, Freeman, & Lipsey, 1999; Judd, Smith, and Kidder, 1991).

The final comparison between causal-comparative and correlational research is based on their purpose. Current authors suggest that the purpose of causal-comparative research is to examine causality and the purpose of correlational research is to examine relationships and make predictions (e.g., Gay, 1996). This is misleading because, first, one can also examine relationships and make predictions in the presence of nonmanipulated categorical variables (i.e., in causal-comparative) and, as discussed above, evidence for causality is obtained by controlling for extraneous variables and by ruling out plausible rival hypotheses (which can be done equally well in causal-comparative and correlational research). However, the idea of making a distinction within nonexperimental quantitative research between approaches dealing with causality and those that do not deal with causality does have merit. This idea will be revisited below, but, first, I examine the origin of the belief that causal-comparative research provides stronger evidence for causality than correlational research.

Where Did the Idea that Causal-Comparative is Superior Come From?

The term causal-comparative appears to have originated in the early 20th century (see Good, Barr, & Scates, 1935). The early writers did not, however, contend that evidence for causality based on causal-comparative research was superior to evidence based on correlational research. For example, according to Good, Barr, & Scates (1935),

> Typically it [causal-comparative] does not go as far as the correlation method which associates a given amount of change in the contributing factors with a given amount of change in the consequences, however large or small the effect. The method [causal-comparative] always starts with observed effects and seeks to discover the antecedents of these effects. (P.533) The correlation method...enables one to approach the problems of causal relationships in terms of degrees of both the contributing and the dependent factors, rather than in terms of the dichotomies upon which one must rely in the use of the causal-comparative method. (P.548)

It was also known at the time that selected extraneous variables could be partialled out of relationships in correlational research.[2] This idea is illustrated in the following (Good et al):

> For the purpose of isolating the effects of some of these secondary factors, a technique generally known as partial correlation is available. It has various names for special forms, including part correlation, semi-partial correlation, net correlation, and joint correlation...That is, the influence of

> many factors upon each other can be separated so that the relationship of any one of them with the general resulting variable (commonly called in statistics the dependent variable) can be determined when this relationship is freed from the influence of any or all of the remaining factors studied. (P.564)

The fallacious idea that causal-comparative data are better than correlational data for drawing causal inferences appears to have emerged during the past several decades, and it has been popularized in some of the educational research texts during that time.

There may be several sources that have led to confusion. First, some may believe causal-comparative research is superior to correlational research for studying causality because a causal-comparative study looks more like an experiment. For example, if a researcher categorized the independent variable it may look more like an experiment than when the independent variable is continuous because of the popularity of categorical independent variables in experimental research.[3]

Second, perhaps the term causal-comparative suggests a strong design but the term correlational suggests a simple correlation (and hence a weak design). I sometimes ask my beginning research methods students which approach is stronger for studying cause and effect: causal-comparative or correlational research. Many respond that causal-comparative is stronger. When I ask them why they believe causal-comparative is stronger, they frequently point out that the word causal appears in the term causal-comparative research but not in the term correlational research.

Third, the term correlational research has often been used as a synonym for nonexperimental research over the years in education and in the other social and behavioral sciences. Unfortunately, this use may lead some people to forget that causal-comparative also is a nonexperimental research method. Causal-comparative research is not experimental research; it is not even quasi-experimental research. Causal-comparative research, just like correlational research, is a nonexperimental research method.

Fourth, perhaps the confusion is linked to a faulty view about the difference between ANOVA (which is linked to causal-comparative research) and correlation/regression (which is linked to correlational research). For example, some writers appear to believe that ANOVA is only used for explanatory research and correlation and regression is limited to predictive research. It is essential that students and teachers of educational research understand that multiple regression can be used for explanatory research (and for the control of extraneous variables) as well as for descriptive and predictive research, and, likewise, ANOVA can be used for descriptive and predictive research as well as for explanatory research (Cohen & Cohen, 1983; Pedhazur, 1997). Obviously, ANOVA and MRC (multiple regression and correlation) are both "special cases" of the general linear model, and they are nothing but approaches to statistical analysis. The general linear model "does not know" whether the data are being used for descriptive, predictive, or explanatory purposes because the general linear model is only a statistical algorithm.

Fifth, perhaps some students and researchers believe causal-comparative research is superior because they were taught the mantra that "correlation does not imply causation." It is certainly true that correlation does not, by itself, imply causation (it is a necessary but not sufficient condition). It is equally true, however, that observing a difference between two or more means does not, by itself, imply causation! It is very unfortunate that this second point is not made with equal force in all of our educational research textbooks. Another way of putting this is that evidence for causality in the simple case of causal-comparative research (two variables with no controls) and in the simple case of correlational research (two variables with no controls) is virtually nonexistent. One simply cannot draw causal conclusions from these simple cases. Some evidence of causality can be obtained by improving upon these simple cases by identifying potential confounding variables and attempting to control for them.

What Should Be Taught in Research Methods Books and Classes?

The terms causal-comparative research and correlational research should be dropped from educational research methods textbooks. Use of these terms is no longer justifiable because too often they mislead rather than inform. The term causal-comparative suggests to our students that it is a strong method for studying causality (Why else would it include the word "cause?"), and the term correlational suggests a statistical technique rather than a research technique (Correlational techniques are also used in experimental research). Writers should have followed Cook and Campbell's advice on this issue. Over twenty years ago, Cook and Campbell (1979) pointed out that "the term correlational-design occurs in older methodological literature...We find the term correlational misleading since the mode of statistical analysis is not the crucial issue" (p.6, emphasis in original).

It is telling that the late Fred Kerlinger (1986), who was one of education's leading research methodologists, made no distinction between causal-comparative and correlational research (or between "ex post facto" research and correlational research). Kerlinger used the term nonexperimental research, which is the term that I believe educational methodologists should readily adopt.[4] Here is how Kerlinger defined the inclusive term nonexperimental research:

> Nonexperimental research is systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Inferences about relations among variables are made, without direct intervention, from concomitant variation of independent and dependent variables. (p.348)

Although Kerlinger originally (1973) called this type of research ex post facto research (which some believe is a synonym for the term causal-comparative research), Kerlinger later (1986) dropped the term ex post facto (probably because it apparently excludes prospective studies). An examination of

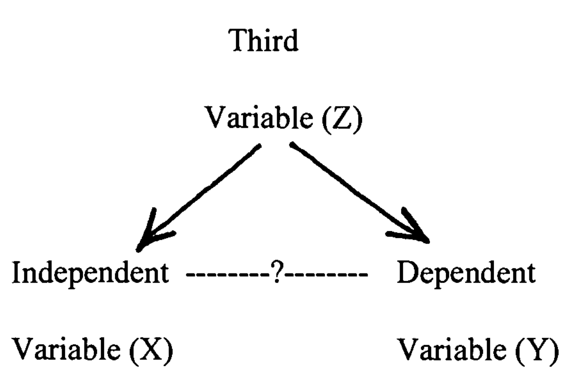
Kerlinger's examples also clearly shows that Kerlinger's nonexperimental research classification is not limited to studies including at least one categorical variable. Kerlinger was an expert on the general linear model, and he would never have contended that causal-comparative studies were superior to correlational studies for establishing evidence of cause and effect.

We need to teach students how to think about causality and teach them that the scaling of a variable (categorical or quantitative) has nothing to do with evidence of causality. For example, when an independent variable is categorical, the comparisons are made across groups. When an independent variable is quantitative, comparisons can be made for the different levels of the independent variable. You can also describe the presumed effect through a functional form such as a linear or quadratic model. It is generally a poor idea to categorize quantitative variables because of the loss of information about amount and process (Kerlinger, p.558; Pedhazur & Schmelkin, 1991, p. 308).[5]

When interest is in causality, researchers should always address the three necessary conditions for cause and effect (Cook and Campbell 1979; Johnson & Christensen, 2000). The first necessary condition is that the two variables must be related (called the relationship or association condition). The second necessary condition is that proper time order must be established (called the temporal antecedence condition). That is, if changes in Variable A cause changes in Variable B, then A must occur before B. The third necessary condition is that an observed relationship must not be due to a confounding extraneous variable (called the lack of alternative explanation condition). There must not remain any plausible alternative explanation for the observed relationship if one is to draw a strong causal conclusion. A theoretical explanation or rationale for the observed relationship is also essential to make sense of the causal relationship and to lead to hypotheses to be tested with new research data.

A potential problem to watch for when studying relationships is that commonly used statistical techniques may miss a relationship. For example, a Pearson correlation coefficient (or any other measure of linear relationship) will underestimate or entirely miss a curvilinear relationship. Model misspecification can also result in failure to identify a relationship. For example, if there is a fully disordinal two-way interaction (where the graph for two groups forms an "X") there will be no main effects, and, therefore, if one of the independent variables is excluded from the study and the interaction is never examined, it will appear that there is no relationship between the included variables (even experimental manipulation and randomization are to no avail here). Simpson's Paradox (Moore and McCabe, 1993, pp. 188-191) can result in a conclusion (based on a measure of bivariate association) that is the opposite of the correct conclusion. One must also be careful in interpreting a relationship when suppression is present (see Cohen and Cohen, 1983, pp. 94-95).

We need to emphasize that nonexperimental research is generally good for identifying relationships (condition one), but it is weak on necessary conditions two (time order) and three (ruling out alternative explanations). Nonexperimental research is weakest on condition three. The key and omnipresent problem is that an observed relationship between an independent variable and a dependent variable may be spurious. That is, the relationship is not a causal relationship; it is a relationship that is the result of the operation of a <u>third variable</u> (see Figure 1).



<u>Figure 1</u> The problem of spuriousness.

Researchers interested in studying causality in nonexperimental research should determine whether a functional relationship (that is presumed to be causal) disappears after controlling for key extraneous variables that represent plausible rival hypotheses. The more tests of this sort a theoretically derived model survives, the better the evidence of causality. The following are also important in establishing evidence for causality: empirical tests of theoretical predictions with new data, replication of findings to rule out chance and sample specific factors, evidence of construct validity, and extensive open and critical examination of the theoretical argument by the members of the research community who have expertise in the specific research domain. Little can be gained from a single nonexperimental research study, and students and researchers must always temper their conclusions. Greater evidence can be obtained through meta-analytic research studies.

Classifying Nonexperimental Research

One effective way to classify quantitative, nonexperimental studies is to classify each study based on the major or primary research objective. The studies can be usefully classified into the categories of descriptive research, predictive research, and explanatory research. To determine whether the primary objective was description, ask the following questions: (1) Were the researchers primarily describing the phenomenon? (2) Were the researchers documenting the characteristics of the phenomenon? If the answer is "yes" (and there is no manipulation), then apply the term descriptive nonexperimental research. To determine whether the primary objective was predictive, ask the following question: Did the researchers conduct the research so that they could predict or forecast some event in the future? If the answer is "yes" (and there is no manipulation), then apply the label predictive nonexperimental research. To determine whether the primary objective was explanatory, ask the following questions: (1)Were the researchers trying to develop or test a theory about a phenomenon to explain how and why it operates? (2) Were the researchers trying to explain how the phenomenon operates by identifying the factors that produce change in it? If the answer is "yes" (and there is no manipulation), then apply the term explanatory nonexperimental research.

Nonexperimental, quantitative studies should also be classified based on the time dimension. Here the types include cross-sectional research, longitudinal research, and retrospective research. In cross-sectional research the data are collected from research participants at a single point in time or during a single, relatively brief time period and comparisons are made across the variables of interest. In longitudinal research the data are collected at more than one time point or data collection period, and the researcher is interested in making comparisons across time. Data can be collected on one or multiple groups in longitudinal research. Two subtypes of longitudinal research are trend studies (where independent samples are taken from a population over time and the same questions are asked) and panel or prospective studies (where the same individuals are studied at successive points over time). The panel or prospective study is an especially important case when interest is in establishing evidence of causality because data on the independent and control variables can be obtained prior to the data on the dependent variable. This helps to establish proper time order (i.e., necessary condition two). In retrospective research, the researcher looks backward in time (typically starting with the dependent variable and moving backward in time to locate information on independent variables that help explain differences on the dependent variable).

The two dimensions just presented (research objective and time) provide important and meaningful information about the different forms nonexperimental research can take (Johnson & Christensen, 2000). Use of these terms will convey important information to readers of journal articles and other forms of professional communication. In short, use of these terms will more clearly delineate what was done in a given research study. Notice that the two dimensions can be crossed, forming a 3-by-3 table. This results in nine very specific forms that nonexperimental research can take (see Table 1).

Table 1

Types of Research Obtained by Crossing Research Objective and the Time Dimension

	Time Dimension		
Research Objective	Retrospective	Cross-Sectional	Longitudinal
Descriptive	Type 1	Type 2	Type 3
Predictive	Type 4	Type 5	Type 6
Explanatory	Type 7	Type 8	Type 9

Two specific examples of the study types shown in Table 1 are mentioned here. First, in the article "Psychological Predictors of School-Based Violence: Implications for School Counselors" the researchers (Dykeman, Daehlin, Doyle, & Flamer, 1996) wanted to examine whether three psychological constructs could be used to predict violence among students in grades five through ten. The psychological constructs were impulsivity, empathy, and locus of control. This study is an example of Type 5 because the research objective was predictive and the data were cross-sectional. A second example is the study titled "A Prospective, Longitudinal Study of the Correlates and Consequences of Early Grade Retention" (Jimerson, Carlson, Rotert, Egeland, & Stroufe, 1997). The researchers in this study identified groups of retained and nonretained students that were matched on several variables and then followed these groups over time. Statistical controls were also used. This study is an example of Type 9 because the research objective was explanatory and the data were longitudinal.

The third and last component of the classification of nonexperimental quantitative research involves the scaling of the independent, dependent, and any control variables that may be included. All three of these variable types can be either categorical or quantitative. Table 2 shows the variable combinations for the case of one independent variable, one dependent variable, and one control variable. Although a study may include multiple independent, dependent, and/or control variables, Table 2 demonstrates one set of combinations.

Table 2

Types of Research Obtained by Crossing Independent Variable Type and Dependent Variable Type By Control Variable Type*

	Control Variable			
	Categorical		Quantitative	
	Independent Variable		Independent Variable	
Dependent Variable	Categorical	Quantitative	Categorical	Quantitative
Categorical	C-C-C	C-Q-C	C-C-Q	C-Q-Q
Quantitative	Q-C-C	Q-Q-C	Q-C-Q	Q-Q-Q

* Table entries were formed using the following order: dependent variable, independent variable, and control variable. The letter C stands for categorical and the letter Q stands for quantitative.

It is important to remember that the scaling of the variables has no necessary relation to the strength of the design for the different research purposes (description, prediction, explanation). The variables may also be measured at one point in time or at more than one point in time regardless of their scaling. The importance of examining the scaling of the variables is for determining the statistical model and type of statistical analysis that is appropriate for the variable combination. For example, if all three variables are categorical (type C-C-C), a three way contingency table or a loglinear model could be used. ANCOVA would be appropriate for type Q-C-Q. It is left as an exercise to the reader to identify the appropriate statistical analysis techniques for the other entries shown in Table 2.

Conclusion

The terms causal-comparative and correlational are dated and misleading and suggest a false dichotomy. Textbook authors should stop misleading educational research students and researchers in-training with the suggestion that causal-comparative research provides better evidence for causality than correlational research and get down to the more important issues surrounding causality and how to design relatively strong nonexperimental designs. Time spent making the causal-comparative versus correlational research distinction will be wasted (think of the opportunity costs). Leading authors in other (non-education) disciplines apparently agree because they have found no need for the distinction between causal-comparative and correlational research (e.g., Babbie, 1998; Checkoway, Pearce, & Crawford-Brown, 1989; Christensen, 2000; Davis & Cosena, 1993; Jones, 1995; Judd, Smith, & Kidder, 1991; LoBiondo-Wood & Haber, 1994; Neuman, 1997; Frankfort-Nachmias & Nachmias, 1992; Malhotra, 1993; Pedhazur & Schmelkin, 1991; Singleton, Straite, & Straits, 1993). Because of the importance of nonexperimental research in education, it is essential that students learn how to develop defensible nonexperimental research studies. This will involve making meaningful distinctions among different forms of nonexperimental research and designing studies to meet the intended research purpose.

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Footnotes

1. Fraenkel's message is one of many in an extensive discussion taking place on the AERA Division-D Internet Discussion Group, spanning several weeks, about the relative strengths of causal-comparative and correlational research. You can access the archives of the discussion from the AERA homepage. The discussion began on February 6, 1998 with a message posted by Burke Johnson and ended on March 5, 1998 with a message posted by Michael Scriven. The discussion took place under several headings including "research methods question," "causal-comparative vs. correlational," "causal-comparative and cause," "Professor Johnson," "the correlation/causal-comparative controversy," "correlational/C-C questionnaire," and "10 reasons causal-comparative is better than correlational."

2. The early writers were also, perhaps, overly optimistic about the power of statistical techniques for control.

3. Although the simple causal-comparative design looks much like the static group comparison design (which is a weak or preexperimental research design), the simple causal-comparative design has even less going for it than this design.

4. If, given the context, it unclear that a study is quantitative then use the term nonexperimental quantitative research.

5. The practice of categorizing quantitatively scaled variables may have developed prior to the widespread use of computers as a result of the ease of the mathematical computations in ANOVA (Tatsuoka, 1993).

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