Conceptual Meaning and Spuriousness in Ratio Correlations: The Case of Restaurant Tipping

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Ratios of one variable over another are frequently used in social psychological research in order to control for a hear relationship between the numerator and the denominator. However, the use of ratio variables can introduce spuriousness into data analyses. This article provides a description and explanation of the problem of spuriousness in ratio correlations and it illustrates this problem with research on restaurant tipping.

Ratios of one variable over another are frequently used in social psychological research to control for a relationship between the ratio's numerator and denominator. For example, social psychologists have used as dependent measures the proportion of message-relevant thoughts generated in response to a persuasive communication (e.g., DeBono, 19871, the ratio of violent to non-violent crime (eg., Anderson & Anderson, 1984), the percentage of time a subject made eye contact while talking (e.g., McClintock & Hunt, 19751, the proportion of bystanders helping (e.g., Latane & Dabbs, 19751, and the proportion of crowd inquiring for Christ (Newton & Mann, 1980). The use of ratio variables such as these can introduce spuriousness into data analysis. Although this problem with ratio variables is widely recognized in sociology (cf., Firebaugh & Gibbs, 1985; Logan, 1982; Long, 1980), psychologists seem largely unaware of it. In order to increase social psychologist's awareness of this issue, we provide an explanation of the problem of spuriousness in ratio correlations and we illustrate this problem with research on restaurant tipping.

Spuriousness in Ration Correlations

Overview

The problem of spuriousness in ratio correlations is best described mathematically. Let Y represent some variable to be put in the numerator of a ratio and let X represent some variable to be put in the denominator. Now, Y can be expressed as a polynomial function of X

$$Y = a + b_1X + b_2\, x^2 + \ldots\, b_i\, x^{n-1} + e,$$

where a, bi, b2, and bi are unknown population parameters and e is the error of prediction. Dividing Y by X is the same as dividing each component in the right-hand side of the above equation by X and then adding the component quotions together

$$Y/X = a\,/\,X + b_1 + b_2\, X + \ldots\, b_i\, X^{n-2} + e/X.$$

The problem with dividing Y by X can be clarified by examining the effects of dividing each of Y's components by X.

Dividing the intercept a by X will result in either a positive or a negative relationship between the ratio a/X and its denominator X depending upon the sign of a. Because a is a constant, all of the variance in a/X is due to X and correlating this ratio with its denominator is no more meaningful than correlating a variable with its inverse. Thus, to the extent that the absolute value of a is large (relative to the mean of Y), dividing Y by X will create a tendency toward a spurious correlation between the ratio Y/X and its denominator X. This spurious relationship will be marginally decreasing because each successive unit change in the denominator of the ratio represents a smaller proportional change in that denominator. This can be easily seen by considering the following progression in the denominator of a ratio with 1 as the numerator - 1 /1, 1/2, 1/3, 1/4, 1/5, etc...

Dividing the polynomial terms b_i X + b2 X2 +... + b_i Xn-1 by X will create a variable with one fewer polynomial terms. This can be seen by ignoring the intercept and error terms and then comparing equations (1) and (2) above. This reduction in the number of polynomial terms is precisely what is desired when a ratio is used to control for the effects of one variable on another. Usually, the investigators expect a strong linear relationship between two variables, so they control for the influence of one on the other by dividing them and eliminating the linear trend. Other times, investigators divide one variable by another in order to turn a theoretically meaningful quadratic relationship into a more easily understood and reported linear effect.

Finally, dividing e by X will change the variance in Y unevenly over the range of X. This means that if the variance in Y is homogeneous across X, then the variance in Y/X will be heterogeneous across X. Heteroscedasticity violates an assumption of parametric analyses and can have serious consequences when it is combined with unequal ns at different levels of X (Hays, 1981, p. 347).

The effects of dividing each of Y's components by X combine to make problematic the interpretation of any relationship between the ratio Y/X and its denominator X. If there is a significant relationship between Y/X and X, it could be due to a non-zero intercept in the relationship between Y and X, a significant quadratic term in the relationship between Y and X, or a combination of these two factors. If there is not a significant relationship between Y/X and X, this could be because there is no significant quadratic relationship between Y and X or because a nonzero intercept offsets any quadratic relationship between Y and X. Only when the intercept of the relationship between Y and X is zero can any linear relationship between Y/X and X be considered equivalent to the quadratic relationship between Y and X that is typically of theoretical interest.

In sum, creating a ratio variable to control for the effect of one variable on another is one method for reducing the number of significant polynomial terms. However, if the intercept of the relationship between a ratio's numerator and denominator is not zero, then the use of a ratio variable will create a spurious correlation between the ratio and its denominator. This will confound any relationship between the ratio and the correlates of its denominator. Furthermore, the use of ratio variables can create heteroscedasticity and its attendant problems.

Conceptual Meaning

Several scholars have defended the use of ratio variables by arguing that the problem of spuriousness does not arise as long as a ratio variable is conceptually and theoretically meaningful (Fuguitt & Lieberson, 1974; Kasarda & Nolan, 1979; Schuessler, 1973). Researchers may be interested in the relationship between two component variables (such as the distance drivers travel and the gasoline they use) or in a relationship between two ratio variables (such as miles per gallon and miles per hour). The relationship between two component variables is not equivalent to the relationship between two ratio variable-n this point, all scholars agree. However, proponents of the conceptual meaning argument add that a relationship between two ratio variables need not be spurious. Rather, they suggest that a relationship between variables is interpretable whenever the variables being related have conceptual meaning. Speed has conceptual meaning when measured in miles per hour. Fuel efficiency has meaning when measured in miles per gallon. Thus, these scholars would endorse an analysis that correlated two ratios measuring speed and fuel efficiency. More generally, they would endorse correlations involving any ratio variable that had conceptual meaning.

Unfortunately the argument about conceptual meaning is an oversimplified tautology that encourages researchers to use ratio variables based on their face validity. Logan (1982) voices a similar criticism when he writes (p. 794): “In sum, the problem with the conceptual or theoretical-meaning resolution ... is not that they are wrong but that they are insufficient. They do not provide with any means of distinguishing causal correlations from artificial ones.”

We contend that the meaningfulness of a ratio variable depends on the meaningfulness of its relationship to other variables. This in turn depends on whether the relationship between the ratio’s numerator and denominator has a zero intercept.

The Case of Restaurant Tipping

To demonstrate these issues, we will now introduce social psychological research on restaurant tipping. This research involves a ratio variable: the tip left by the dining party expressed as a percentage of the restaurant bill. This ratio would seem to have conceptual meaning. Its meaning is evident to social psychologists, who use percent tip as a measure in restaurant research (e.g., Crusco & Wetzel, 1984; Cunningham, 1979; Lynn & Latane, 1984). Moreover, the ratio of tip-to-bill has meaning to restaurant diners as shown by their general compliance with the 15% tipping norm (Freeman, Walker, Borden, & Latane, 1975; Lynn & Latane, 1984). Thus percent tip appears to meet the conceptual meaning criterion for the appropriate use of ratio variables. We hope to demonstrate the spuriousness of correlations involving percent tip and thus to illustrate both the problem of spuriousness in ratio correlations and the inadequacies of the argument about conceptual meaning.

Several studies have found that the number of people in a restaurant dining party was negatively related to the percent of bill size they left as a tip (Freeman et al., 1975; Lynn & Latane, 1984, Study 1; May, 1978; Pearl & Vidman, 1988). Three explanations have been advanced to explain this relationship. It has been attributed to:

1) a diffusion of the shared responsibility that each group member has for the waiter or waitress (Freeman et al., 19751,
2) an equitable adjustment for the smaller per-person service effort required to wait on larger tables (Snyder, 1976), and
3) a cost reducing adjustment for the larger bill sizes acquired by larger tables (Elman, 1976).

Although all of these social processes are possible explanations for the relationship between percent tip and group size, it is also possible that this relationship does not reflect any social process at all. Instead, it may be attributable to a statistical artifact associated with the use of a ratio variable like percent tip.

The previous discussion about spuriousness in ratio Correlations is relevant to the relationship between percent tip and group size. If the relationship between tip amount and bill size has a positive intercept, then dividing tip amount by bill size may create a spurious negative correlation between percent tip and bill size. This spurious negative relationship would then contaminate the relationship between percent tip and any variable strongly correlated with bill size. Given that group size is strongly related to bill size, this contamination would result in a spurious negative correlation between percent tip and group size.

Reanalysis of Lynn and Latane (1984)

In order to illustrate the statistical problems with ratio correlations, we reanalyzed the group size effect on percent tip reported by Lynn and Latane (1984: Study 1). We began the reanalysis by noting the positive y-intercept in the equation for predicting tip amount from bill size. Given the intercept, we anticipated an inverse correlation between percent tip and bill size that could explain Lynn and Latane's inverse correlation between percent tip and group size. We reanalyzed these data with partial correlational techniques and with a measure that corrects for the positive intercept. We then scrambled the data to analyze relationships that involved an obviously meaningless ratio. These analyses should indicate whether Lynn and Latane's group size effect is a statistical artifact and, more generally, whether correlations are valid when they involve ratios (such as percent tip) that appear to have conceptual meaning.

Data Set

Lynn and Latane (1984) interviewed 169 groups of diners as they left an International House of Pancakes restaurant. The variables they recorded and analyzed from these interviews were group size, bill size, tip amount, number of separate checks, customer's gender, and customer's ratings of the restaurants' atmosphere, food, and service. These variables were retained in the reanalysis with only one change. The customer's gender variable was originally coded as male, female, or both depending on the sex of the person or persons paying the check. However, in this reanalysis, the "both" category was collapsed with the "male" category to form a binomial variable-customer's gender was coded as all female or not.

Results

Tipping and bill size. A simultaneous multiple regression of tip amount on bill size and bill size squared (tip = .236 + .096 bill + .OOO bill2) accounted for 46% of the variance in tip amount ($F(2,166) = 70.49$, $p < .0001$). The intercept of this equation was significantly different from zero (t(166) 2.40, $p < .02$) as was the linear component of bill size ($t(166) = 3.80$, $p < .001$). However, the quadratic component of bill size was not significant ($t(166) = .06$, n.s.). These results indicate that people tipped more the greater their bill sizes and that this increase was not marginally decreasing.

Because the intercept of the relationship between tip amount and bill size was 23 cents, the division of tip amount by bill size should create a spurious negative correlation between percent tip and bill size. A comparison of the quadratic trend of tip amount on bill size with the linear trend of percent tip on bill size supports this expectation. The quadratic component of bill size accounted for almost none (.001%) of the variance in tip amount and was not significant (see above). In contrast, the linear effect of bill size accounted for 9.7% of the variance in percent tip and this effect was highly significant ($r = -.31$, $n = 169$, $p < .0001$).

Tipping and group size. Lynn and Latane (1984) reported that percent tip was inversely related to group size r = -.203, p < 001. Thus, the larger the dining party, the smaller was the tip as a percentage of the party's bill. We note that this correlation could be a spurious byproduct of the use of a ratio variable. If so, there should be no relationship between tipping and group size in a statistical analysis that partials the linear effects of bill size from tip amount. To assess this reasoning, we computed the semipartial correlation between group size and that part of tip amount that was unrelated to bill size[1]. This semipartial correlation was nonsignificant, sr = .061, $F(1, 166) = 2.04$, n.s. Larger dining parties did not leave smaller tips.

In our view, the artificial relationship between percent tip and group size reflects a positive intercept in the regression equation for predicting tip amount from bill size2. If our interpretation is valid, there should be no relationship between group size and a measure of tipping that compensates for this intercept term. We defined a corrected percent tip for each of the 169 dining parties in Lynn and Latane (1984). In their sample, the regression equation for predicting tip amount (T) from bill size (B) was T = .232 + .097B. Using the y-intercept from this equation, we defined a new measure, corrected percent tip = (T - .232)/B. If our reasoning about ratio variables is valid, this corrected measure should be unrelated to group size. In fact, the two are unrelated. Corrected percent tip and group size yield an r = + .11, n.s. Neither the semipartial r nor this corrected percent tip provide evidence for an inverse relationship between tipping and group size.

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[1] The square of this semipartial correlation (sr^2) reflects the proportion of the variation in bill adjusted tip amount that is accounted for by group size. Another statistic that could have been used is the partial correlation between that part of group size unrelated to bill size and that part of tip amount unrelated to bill size. The square of this partial correlation (pr^2) would reflect the proportion of variation in bill adjusted tip amount that is accounted for by bill adjusted group size. It is important to point out that the tests of statistical significance for semipartial correlations and for partial correlations are identical (Cohen & Cohen, 1975, p. 108). Thus, our conclusions would not have been altered had we chosen to report partial correlations coefficients rather than semipartial ones.

[2] Correlations between a ratio and a third variable also assume that the third variable does not interact with the ratio's denominator when affecting the numerator. Thus, a spurious relationship between group size and percent tip could also arise if group size interacts with bill size in affecting tip amount. We tested this possibility with Lynn and Latane's (1984: Study 1) data and found no such interaction ($F(1,165) = .00$, n.s.).

Table 1

Comparison of Correlations Involving Percent Tip, Residual Tip, and Bill Size in the Reanalysis of Lynn and Latane (1984)

Variable	Percent Tip	Residual Tip	Bill Size
Group size	-.20*	.06	.83*
No. separate chks.	-.13	-.11	.39*
Atmos. rating	.04	.08	-.10
Food rating	.04	.05	.06
Service rating	.12	.07	-.11
Customer's gender	.27*	.25*	-.09

*These correlations are significant beyond the .05 level.
**These are semipartial correlations with tip amount after partialing out the linear effects of bill size.

Homoscedasticity. Statisticians note that correlational analyses assume homoscedasticity-that is, equal variance in a variable across levels of another variable. White (1980) has offered a test of this assumption. We applied White's tests for homoscedasticity to three different regression models: one that predicted percent tip from group size; a second that predicted, from group size, corrected percent tip (see above); and a third that predicted group size from bill size and tip amount. White's *x2* tests indicate strong heteroscedasticity in the model involving percent tip (~ ~ (=2 12).4 7, *p c* .005), weaker heteroscedasticity in the model involving corrected percent tip (~ ~ (=2 8).2 2, *p c* .02), and no heteroscedasticity in the two-variable model predicting group size (~ ~ (=5 4).4 8, n.s.). This latter model yields the nonsignificant semipartial correlation we reported above between group size and that portion of tip amount that is unrelated to bill size.

Tipping and other variables*.* The spurious negative correlation between percent tip and bill size should contaminate the relationship between percent tip and all of the correlates of bill size. Lynn and Latane (1984) reported correlations of percent tip with several variables. Yet in their analyses, the only variable other than group size that was correlated with bill size was the number of separate checks at each table. Moreover, this latter correlation was modest ($r = .39$, $n = 169$, p c .0001). Thus, it is unlikely that the use of percent tip produced any other spurious correlations in the Lynn and Latane report. To verify this, the zero-order correlations between the other variables in this study and percent tip were compared to the semipartial correlations between these variables and tip amount (with bill size partialed out). In no case other than group size were these correlations sizably different from one another (see Table 1).

Discussion

The results of this reanalysis suggest that Lynn and Latane's (1984) group size effect on tipping merely reflects a positive intercept in the relationship between tip amount and bill size; it does not reflect deviations from linearity in the relationship between tip amount and bill size. We have argued that this intercept based relationship between percent tip and group size is theoretically meaningless. In order to more dramatically demonstrate this, we now report a scrambled-data simulation (a16 Logan, 1982) of the restaurant tipping data.

Scrambled-Data Simulation

Program

We wrote a computer program that would randomly permute the tip amounts (7') left by the 169 dining parties in Lynn and Latane (1984: Study 1). After scrambling tip amounts, the program created a case by pairing a randomly chosen value of T with a particular dining party's bill size (B) and group size (GI. The resulting case was partially meaningful: A dining party's bill size was paired with it's group size to preserve the relationship between B and G. Otherwise, the case was meaningless: A given dining party's bill size and group size were paired with another dining party's tip amount (T). From the 169 cases that resulted from permuting tip amounts, the program computed several statistics, including the Pearson product-moment correlation (r) between percent tip (T/B) and group size (G). The program was run 1000 times, with 1000 independent random permutations of tip amount. Statistics were computed for each of the l000 iterations.

Results

The program resulted in 1000 correlations between group size and a meaningless measure of percent tip. The 1000 correlations ranged in value from -.431 to -.154. The median correlation was -.286; the mean was -.288. The correlations had a standard deviation of .043. Lynn and Latane (1984: Study 1) reported a correlation of -.203 in the unscrambled data from these dining parties. This inverse correlation was smaller (in absolute value) than most of the correlations in the scrambled-data simulation. Indeed, of the 1000 scrambled-data rs, only 15 were smaller in absolute value than -.203. This is because the scrambled-data generated relationships between tip amount (77 and bill size (B) whose slopes were close to zero and whose intercepts were close to the mean tip amount (85.2 cents). Because these intercepts were larger than the 23-cent intercept reported by Lynn and Latane they created a larger spurious relationship between T and B.

We maintain that the use of ratio variables is inappropriate whenever there is a non-zero intercept in the regression equation that predicts the numerator of a ratio from the denominator of the ratio. This suggests that a ratio measure of tipping that corrected for this intercept, (T-a)/B, would yield valid conclusions. We computed the corrected tipping ratio from our scrambled-data simulation. For each of the 1000 permutations of tip amount, we noted the y-intercept (a) in the regression equation for predicting tip amount from bill size. We then determined the value of (T-a)/B for each of the 169 meaningless cases in the permutation, and correlated this corrected ratio with the case's group size (G). This procedure resulted in 1000 Pearson product-moment correlations which we call the corrected ratio correlations. If a non-zero intercept accounts for the inverse relation between percent tip and group size, then these corrected ratio correlations should be 0. Consistent with this expectation, group size was uncorrelated with the corrected ratio measure of tipping (T-a)/B. The 1000 corrected ratio correlations had a mean of .006 and a median of .004. These rs ranged in magnitude from -.186 to +.232; their standard deviation was .066. By the usual tests, 20 of these lo00 correlations would be judged significant at the two-tailed .05 level. This is a somewhat smaller number than the 50 Type 1 errors that would be expected by chance. However, previous analyses indicated that the variance in corrected percent tip was heterogeneous across different levels of group size (with larger variances and larger ns at the smaller group sizes), so the small number of Type I errors reported above may be explained by the conservativeness of regression analyses that combine unequal ns with larger variances in those cells with larger numbers of subjects.

We have argued that partial correlation techniques are more valid than the use of ratio correlations. In particular, we used the semipartial correlation between group size (G) and that portion of tip amount (T) that is independent of bill size (B)-that is, rG (T•B) as a test for the group size effect. If this is a legitimate technique, then the value of this semipartial correlation should be 0 for meaningless data. We computed the semipartial correlation rG (T•B) for each of the 1000 iterations of our scrambled data simulation. The resulting 1000 correlations had a mean of -.001 and a median of .000. They ranged from -.140 to +.163 and had a standard deviation of .044. With formulas in Cohen and Cohen (1975, p. 107), we assessed each of our 1000 scrambled semipartial correlations for statistical significance at the two-tailed .05 level. Fifty-four of the 1000 semi-partial rs were statistically significant. Twenty-seven of our significant correlations were positive; 27 were negative. In short, the distribution of our semipartial correlations was roughly symmetric about 0 and had a variability that would have been produced by chance.

Discussion

The results of this simulation demonstrate that a non-zero intercept in the relationship between tip amount and bill size can create a group size effect on a theoretically meaningless measure of percent tip-a measure produced by the random scrambling of tip amounts. This measure is theoretically meaningless because it does not reflect changes in the tips people left as a function of other variables. However, the intercept of the relationship between scrambled tip amount and bill size was meaningful: It reflected the mean tip amount left by all the parties. This meaningful intercept created the observed relationship between scrambled percent tip and group size, but few people would argue that this makes the relationship theoretically meaningful. An analogous argument can be made about the group size effect reported by Lynn and Latane (1984). Our reanalysis indicated that this effect was produced by a non-zero intercept in the relationship between tip amount and bill size. This intercept may be meaningful-it may reflect a minimum tip that customers feel obligated to pay as rent for occupying a table. However, the group size effect on percent tip created by this intercept is not itself psychologically meaningful.

Conclusion

The results of the reanalysis and the simulation reported above suggest that Lynn and Latane's (1984) group size effect on percent tip is a statistical artifact rather than a psychologically meaningful phenomenon. This statistical artifact explanation for the relationship between percent tip and group size resembles Elman's (1976) cost-adjustment explanation in that it emphasizes the role of bill size as a confound. However, these explanations are different. Elman's explanation suggests that the negative correlation between percent tip and bill size is psychologically meaningful and is due to a deviation from linearity (i.e., a quadratic trend) in the relationship between tip amount and bill size. In contrast, the statistical artifact explanation suggests that the negative correlation between percent tip and bill size merely reflects a positive intercept in the relationship between tip amount and bill size. The reanalysis of Lynn and Latane (1984) supports the statistical artifact explanation over Elman's (1975) cost-adjustment explanation.

The use of the ratio variable percent tip spuriously created Lynn and Latane's (1984) negative relationship between tipping and group size. This illustrates the problem of spuriousness in ratio correlations, but does not completely invalidate a negative relationship between bill size adjusted tips and group size. Freeman et al.'s (1975) original discovery of such a group size effect remains legitimate because the relationship between tip amount and bill size had a non-positive intercept in that study. May's (1978) and Pearl and Vidman's (1988) correlations between percent tip and group size may also be meaningful, but this cannot be determined because the authors did not report the intercept in the relationship between tip amount and bill size in those studies. It should be noted, however, that several studies (e.g., Crusco & Wetzel, 1984; Cunningham, 1979; Lynn, 1988; Lynn & Latane, 1984, Study 2) have failed to replicate Freeman's et al.'s (1975) original group size effect on tipping. Given this record, our demonstration that one (and possibly more) of the replications of this effect is a statistical artifact does weaken confidence in its reliability. At the very least, the effect is less generalizable than commonly assumed.

The spuriousness of Lynn and Latane's (1984) group size effect on percent tip illustrates the inadequacies of the argument that spuriousness does not arise in relationships involving conceptually meaningful ratio variables. Percent tip appears conceptually meaningful, but its relationships to bill size and group size are spurious. The conceptual meaning argument is an overly simple tautology-it does not provide a means of distinguishing meaningful from non-meaningful ratio variables. We maintain that a ratio variable has conceptual and theoretical meaning only when its relationships with other variables are meaningful and that ratio correlations are meaningful only when the relationship between the ratio's numerator and denominator has a zero intercept.

This discussion and demonstration of the potential problem with ratio variables has several implications for researchers in social psychology. Researchers who want to use a ratio variable need to first examine the relationship between the ratio's numerator and denominator. If the intercept of this relationship is sizably different from zero, then the uncorrected ratio variable should not be used. How large must this intercept be before the use of a ratio variable produces invalid results? This question is difficult to answer. One reasonable response is to say that the intercept must be significantly different from zero given the standard .05 alpha level. If the intercept term is not significant, then the true population intercept may be zero and a ratio variable would validly reflect the relationships between the population parameters being estimated. Another reasonable response to this question is to recommend comparing the results from analyses using a ratio variable with the results from alternative analyses like those reported above. If these results lead to different conclusions, then the non-zero intercept is too large for the ratio correlation to be confidently interpreted.

If the use of a ratio variable is judged to be inappropriate, then the researchers must choose between the use of the corrected ratio variable (previously described) and the use of residuals from regression analyses on the ratio's components (see Cohen & Cohen, 1975). The corrected ratio variable and the residuals will have very different variances, because division changes the variance in the numerator unequally across different levels of the denominator. Thus, when the data contain unequal cell sizes the decision about which variable to use should be made in favor of the measure with the greatest homogeneity of variance. This is true because the combination of unequal cell sizes with heteroscedaciticity seriously compromises parametric analyses (Hays, 1981). On the other hand, when the data contain equal cell sizes', then parametric analyses are fairly robust with respect to the assumption of homogeneity of variance and the choice of measures can be made on the basis of convenience and audience receptivity.

If the use of an uncorrected ratio variable is judged to be appropriate (because the relationship between the ratio's components has a zero intercept), then researchers should feel free to employ the ratio. However, the potential problem of spuriousness in ratio correlations should be addressed-and the researchers use of the uncorrected ratio should be justified. Without such justification, readers would have no way of knowing whether the reported ratio correlations were meaningful.

References

Anderson, C.A., & Anderson, D.C. (1984). Ambient temperature and violent crime: Tests of the linear and curvilinear hypothesis. Journal of Personality and Social Psychology, 46, 91-97.

Cohen, J., & Cohen, P. (1975). *Applied multiple regression/correlation analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum.

Crusco, A.H., & Wetzel, C.G. (1984). The Midas touch: The effects of interpersonal touch on restaurant tipping. *Personality and Social Psychology Bulletin,* 12,512-517.

Cunningham, M.R. (1979). Weather, mood, and helping behavior: Quasi experiments with the sunshine Samaritan. *Journal of Personality and Social Psychology*, 37, 1947-1956.

DeBono, K.G. (1987). Investigating the social-adjustive and value expressive functions of attitudes: Implications for persuasion processes. *Journal of Personality and Social Psychology*, 52,279-287.

Elman, D. (1976). Why is tipping “cheaper by the bunch.” Diffusion or just desserts? *Personality and Social Psychology* Bulletin, 2, 307.

Firebaugh, *G.,* & Gibbs, J.P. (1985). User’s guide to ratio variables. *American Sociological Review*, 50, 713-722.

Freeman, S., Walker, M., Borden, R., & Latane, B. (1975). Diffusion of responsibility and restaurant tipping: Cheaper by the bunch. *Personality and Social Psychology Bulletin,* 1, 584-587.

Fuguitt, G.V., & Lieberson, S. (1974). Correlations of ratios or difference scores having common terms. In H.L. Costner (Ed), *Sociological methodology* (pp. 124-144). San Francisco: Jossey-Bass.

Hays, W.L. (1981). *Statistics* (3rd ed.). New York: Holt, Rinehart and Winston.

Kasarda, J.D., & Nolan, P.D. (1979). Ratio measurement and theoretical inference in social research. *Social Forces*, 58,212-227.

Latane, B., & Dabbs, J. (1975). Sex, group size, and helping in three cities. *Sociomety*, 38,180-194.

Logan, C.H. (1982). Problems in ratio correlation: The case of deterrence research. *Social Forces*, 60,791-810.

Long, S.G. (1980). The continuing debate over the use of ratio variables: Social Psychology, 37,1947-1956. Facts and fiction. In K. F. Schuessler (Ed.), *Sociological methodology* (pp. 37-67). San Francisco: Jossey-Bass.

Lynn, M. (1988). The effects of alcohol consumption on restaurant tipping. *Personality and Social Psychology Bulletin*, 14, 87-91.

Lynn, M., & Latane, B. (1984). The psychology of restaurant tipping. *Journal of Applied Social Psychology, 14,551-563.*

May, J. (1978). *Tip* or *treat: A study of factors affecting tipping behavior.* Unpublished masters thesis, Loyola University of Chicago.

McClintock, C.C., & Hunt, R.G. (1975). Non-verbal indicators of affect and deception in an interview setting. *Journal of Applied Social Psychology*, 5, 54-67.

Newton, J.W., & Mann, L. (1980). Crowd size as a factor in the persuasion process: A study of religious crusade meetings. *Journal of Personality and Social Psychology*, 22,874-883.

Pearl, R.B., & Vidman, J. (1988). *Tipping practices of American households in restaurants and other eating places*: 1985-86. Summary report to the IRS under contract TIR 86-279 with the Survey Research Laboratory, University of Illinois.

Schuessler, K. (1973). Ratio variables and path models. In A.S. Goldberger & O.D. Duncan (Eds.), *Structural equation models in the social sciences* (pp. 201-228). New York: Seminar Press.

Snyder, M.L. (1976). The inverse relationship between restaurant party size and tip percentage: Diffusion or equity? *Personality and Social Psychology Bulletin*, 2, 308.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica*, 48, 81 7-838.