Supplemental material on graphical presentation methods to accompany:

Preacher, K. J., & Kelley, K. (2011). Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychological Methods*, *16*, 93-115.

In the paper we discuss several ways of communicating effect size in mediation analysis. In this supplemental document we present three graphical methods researchers may consider to supplement the presentation of mediation analyses. R functions to obtain mediation effect plots and effect bars can be found in the R package MBESS (Kelley & Lai, 2010; Kelley, 2007).

Cumming and Finch (2001) note that “vivid graphical representations can assist greatly in the understanding of statistical concepts. It can be even better if these representations are dynamic and interactive” (p. 537). Graphical displays of effects can quickly communicate information and greatly enhance understanding. In line with recommendations of the APA Task Force on Statistical Inference (Wilkinson et al., 1999), graphical representation can be used to enhance the interpretability of mediation effects. With this goal in mind, we now discuss three graphical methods to complement effect size estimates for mediation.

Mediation Effect Plots

Merrill (1994; see also MacKinnon, 2008; MacKinnon et al., 2007; Sy, 2004) presents a method that involves plotting the indirect effect as the vertical distance between two lines. Fritz and MacKinnon (2008) present a detailed exposition of this method, which we summarize here. We apply the method using the SPBY data example in Figure S1; Figure S2 contains a highly magnified section of Figure S1 for increased clarity and detail. In Figures S1 and S2, the two horizontal lines correspond to the predicted values of Y regressed on X at the mean of X and at one unit above the mean of X (here, $Y = 1.65$ and 1.61, respectively). The distance between these two lines is thus $\hat{c}$. The two vertical lines correspond to predicted values of M regressed on X at the same two values of X (here, $M = 5.90$ and 6.19). The distance between these lines is $\hat{a}$.

Finally, lines corresponding to the regression of *Y* on *M* (controlling for *X*) are plotted for the same two values of *X*. These are the tilted lines in Figures S1 and S2. The estimated indirect effect $\hat{a}\hat{b}$ is the vertical distance between the middle line (corresponding to the mean of *X*) and the lower horizontal line. The direct effect $\hat{c}'$ is the vertical distance between the middle line and the upper horizontal line (note that these two distances add to $\hat{c}$, the total effect). The slopes of the diagonal lines are $\hat{b}$. Thus, all of the important quantities are included in this plot. Fritz and MacKinnon (2008) provide SAS and R code for making such plots in simple mediation models and in mediation models including an interaction term. We also supply R code and incorporate it into MBESS to implement this plotting technique. The point of these figures is to express the results of the mediation model visually with a plot that highlights the most relevant quantities. The figures are meant to supplement the reported effect sizes and their confidence intervals.

Effect Bars

Second, *effect bars* (Bauer, Preacher, & Gil, 2006) may be used to plot the results of a mediation analysis compactly. Effect bars represent, in a single metric, the relative magnitudes of several values that are important for interpreting indirect effects, including the observed values of c' and c, with zero and the most extreme possible value of c to serve as benchmarks for interpretation. The most extreme possible c value, given the observed variances of *X* and *Y*, is simply the ratio of the standard deviations of *Y* and *X* multiplied by the sign of $\hat{c}$. The indirect effect ($c - c'$) is depicted as the distance between c and c' on the bar (see Figure S3).

Venn Diagrams

Venn diagrams (or *ballantines*; Cohen, Cohen, West, & Aiken, 2003), like the one in Figure 2 of the manuscript for our running SPBY example, are often used to illustrate the degree to which two variables share common variance. Each circle in such a diagram represents the variance in a variable, standardized to have area = 1. The overlap of two circles represents shared variance. For example, in Figure S4 Panel A, given that the correlation of *X* and *Y* is r_{YX}, area *b* represents the proportion of variance shared in common by *X* and *Y*, or r_{YX}^2.

We might extend the ballantine to include all three variables in a mediation model. In Figure S4 Panel B, ($b + e$) represents r_{YX}^2, ($d + e$) represents r_{MX}^2, and ($f + e$) represents r_{YM}^2. Areas *b*, *d*, and *f* represent squared semipartial correlations, and area *e* is the graphical equivalent to MacKinnon's $R_{4.5}^2$, discussed in the manuscript. Diagrams such as this give an immediate impression of the absolute and relative magnitudes of the relationships among *X*, *M*, and *Y* in terms of shared variance. For example, the ballantine in Figure S4 Panel C shows that *X* and *Y* are strongly related, but *M* is only marginally related to both *X* and *Y*. Panel D shows a case in which *X* and *Y* are completely uncorrelated, but both *X* and *Y* are marginally related to *M*. In both Panels C and D, little or no mediation is evident. See Ozer (1985) for more information on the use of Venn diagrams in the context of multiple regression.

References

Bauer, D. J., Preacher, K. J., & Gil, K. M. (2006). Conceptualizing and testing random indirect effects and moderated mediation in multilevel models: New procedures and recommendations. *Psychological Methods*, *11*, 142-163.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Erlbaum.

Cumming, G., & Finch, S. (2001). A primer on the understanding, use and calculation of confidence intervals that are based on central and noncentral distributions. *Educational and Psychological Measurement*, *61*, 532-575.

Fritz, M. S., & MacKinnon, D. P. (2008). A graphical representation of the mediated effect. *Behavior Research Methods*, *40*, 55-60.

Kelley, K. (2007). Methods for the behavioral, educational, and social sciences: An R package. *Behavior Research Methods*, *39*, 979-984.

Kelley, K. & Lai, K. (2010). MBESS (Version 3.0.0) [Computer software and manual]. Retrieved from http://www.cran.r-project.org/.

MacKinnon, D. P. (2008). *Introduction to statistical mediation analysis*. Mahwah, NJ: Erlbaum.

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology*, *58*, 593-614.

Merrill, R. M. (1994). *Treatment effect evaluation in non-additive mediation models*. Unpublished dissertation, Arizona State University.

Ozer, D. (1985). Correlation and the coefficient of determination. *Psychological Bulletin*, *97*, 307-315.

Sy, O. S. (2004). *Multilevel mediation analysis: Estimation and applications*. Unpublished dissertation, Kansas State University.

Wilkinson, L., & the Task Force on Statistical Inference (1999). Statistical methods in psychology journals. *American Psychologist*, *54*, 594-604.

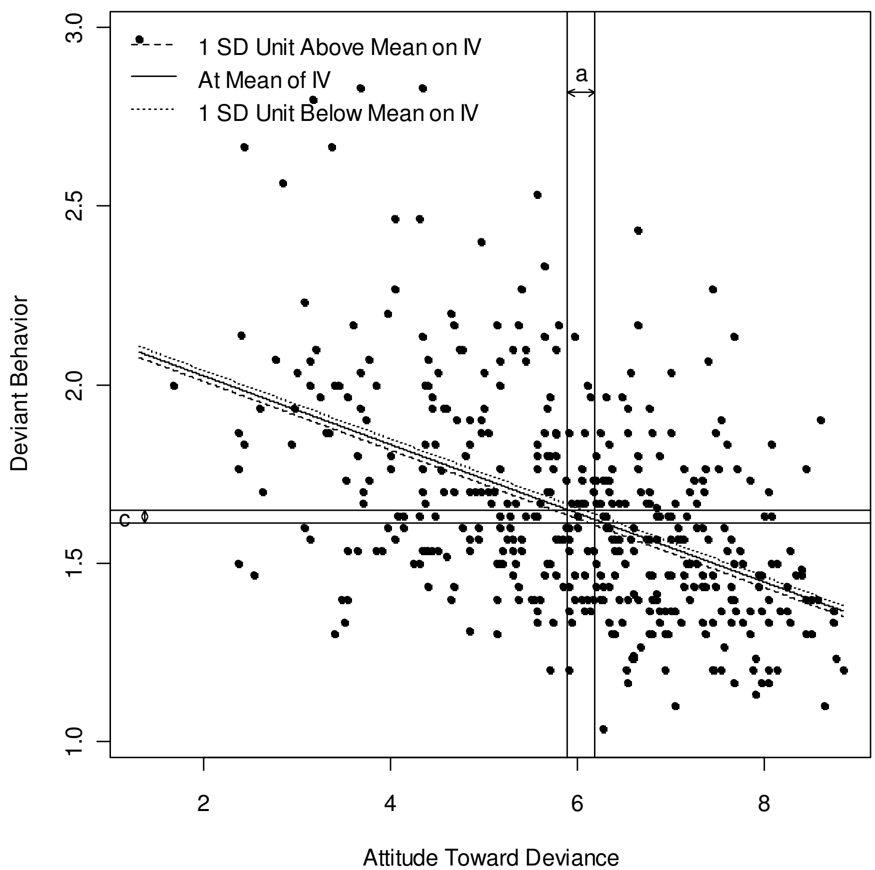

Figure S1. Mediation effect plot for the indirect effect of VAC on DVB through ATD. The two horizontal lines correspond to the predicted values of *Y* at the $\bar{X}$ and $\bar{X} + SD_X$. The distance between these two lines is $\hat{c}$. The two vertical lines correspond to predicted values of *M* at the same two values of *X*. The distance between these lines is $\hat{a}$. Tilted lines correspond to the regression of *Y* on *M* (controlling for *X*) at $\bar{X}$ and $\bar{X} \pm SD_X$, and have slopes of $\hat{b}$. The estimated indirect effect $\hat{a}\hat{b}$ is the vertical distance between the middle line (corresponding to the mean of *X*) and the lower horizontal line. The direct effect $\hat{c}'$ is the vertical distance between the middle line and the upper horizontal line.

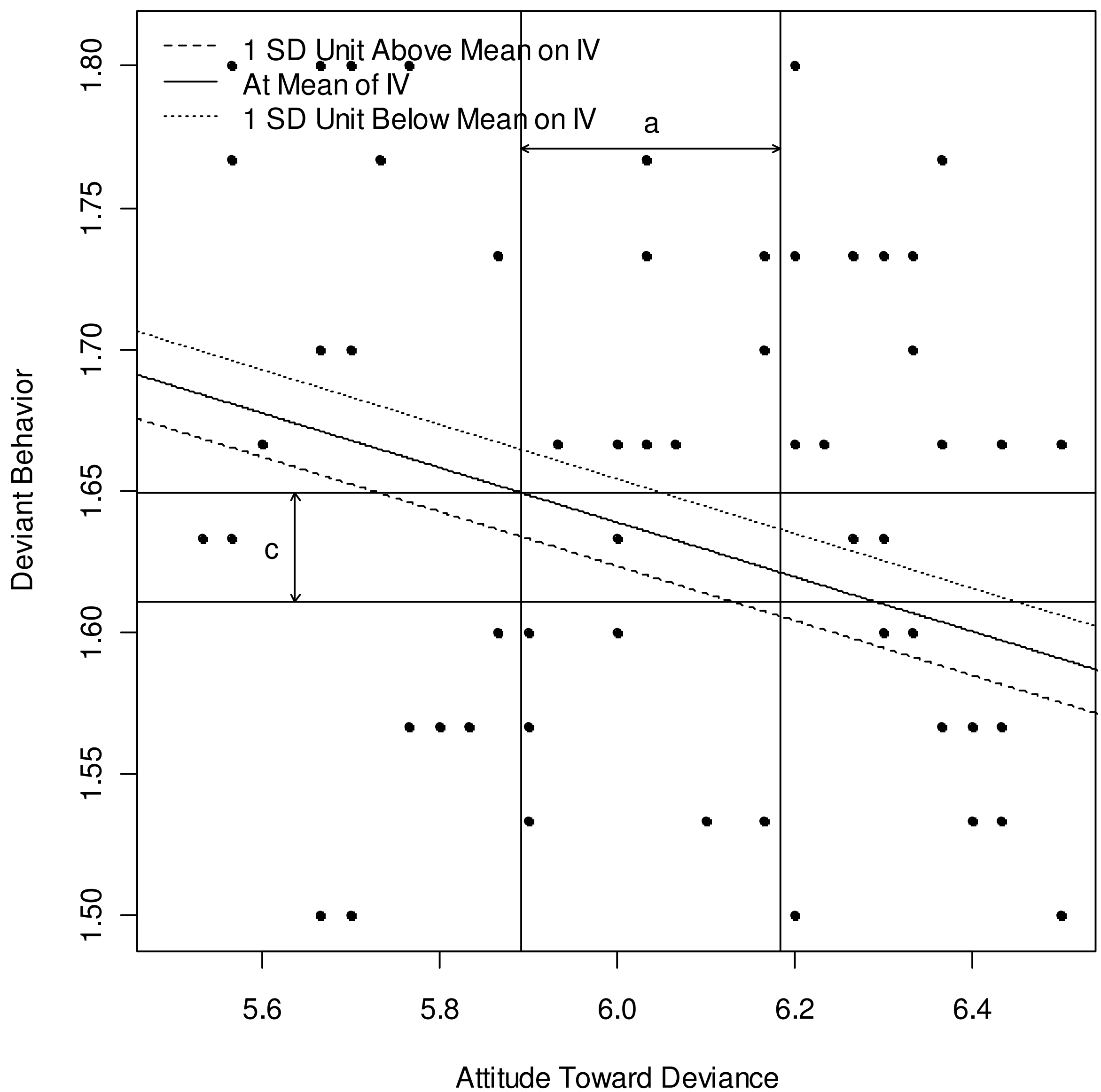

Figure S2. Magnification of the central portion of the mediation effect plot in Figure S1.

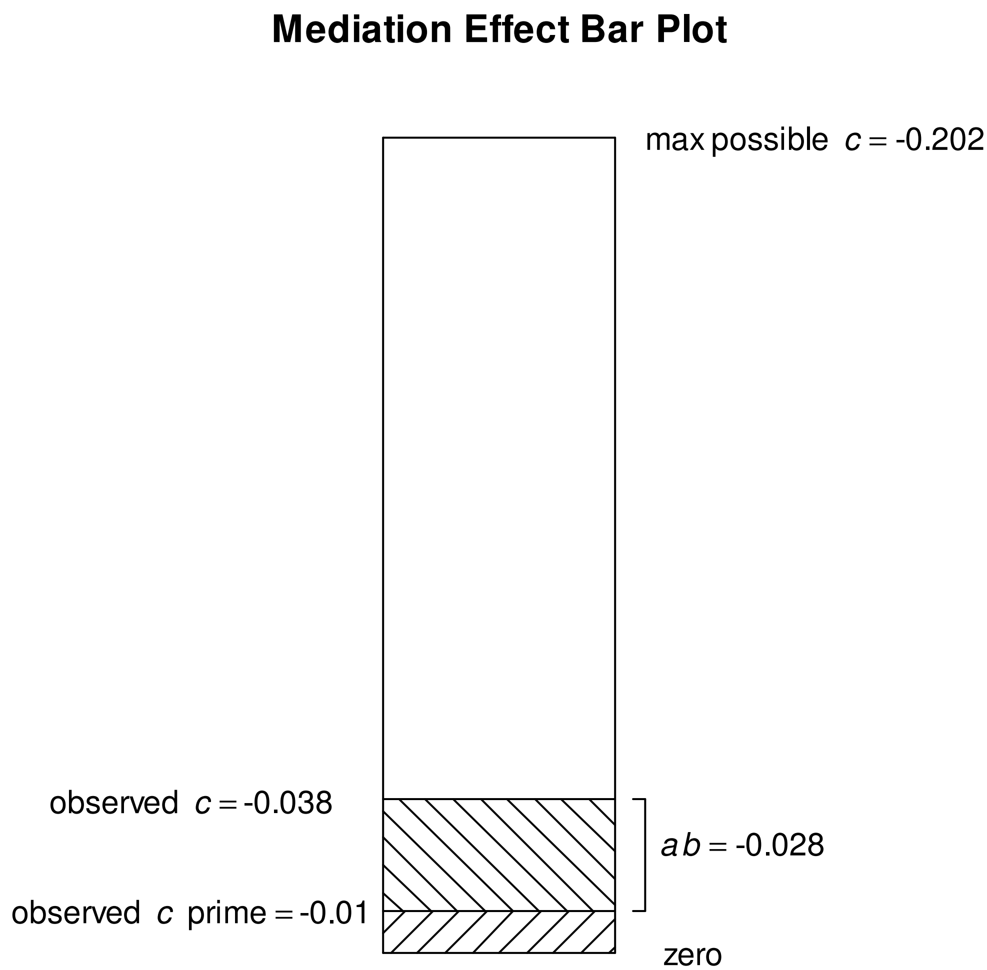

Figure S3. Effect bar plot for the SPBY example. Positions on the bars correspond to effects of *X* on *Y* ranging from zero to the most extreme possible value given the variances of *X* and *Y*. The bars also include the observed values of *c* and *c*′, the difference between these points being the indirect effect *ab*.

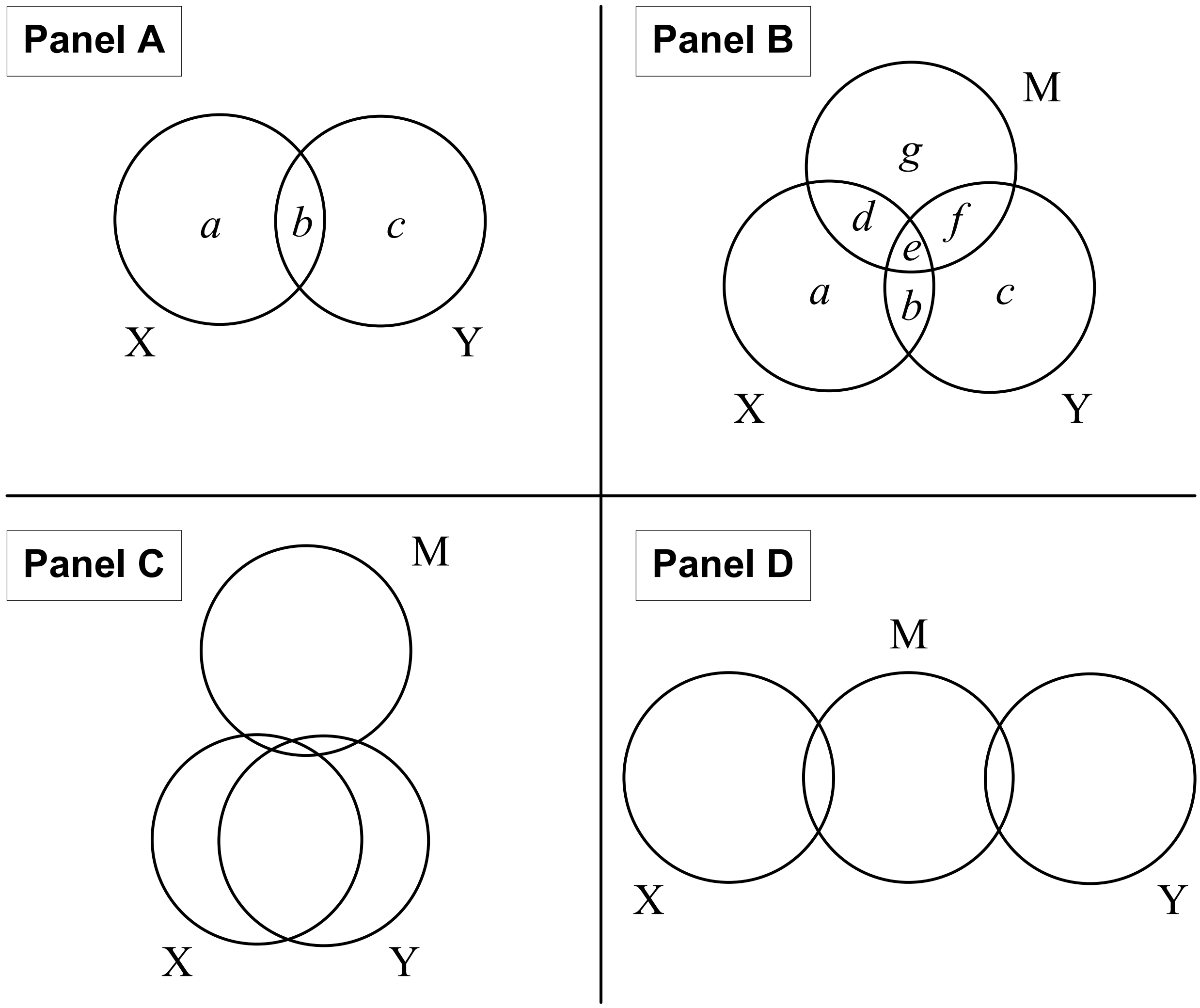

Figure S4. Four Venn diagrams depicting proportions of variance shared among *X*, *M*, and *Y*. Each circle represents the total variance of a variable, and the overlap of two circles represents the portion of variance shared in common by two variables.