The Effect of Item Intraclass Correlation on Multilevel Confirmatory Factor Analysis: Is Ignoring Multilevel Ever Justified?

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In many circumstances, researchers collect data that have an internal multilevel structure, ignore the multilevel structure of data, and use methods designed for use with single-level data. In this study, we examine the results of ignoring the macro level (i.e., disaggregation) on micro-level standardized coefficients (i.e., standardized factor loading and factor correlation) in confirmatory factor analysis (CFA). We found that, if both levels have the same factor structure, the disaggregated standardized coefficients were equal to the weighted average of macro- and micro-level counterparts. Thus, when the micro- and macro-level standardized parameters were equal, the disaggregated parameter estimates were unbiased. The weights were given more to macro level parameters when the intraclass correlation (ICC) was high, leading to more bias in micro-level standardized coefficients. Practical implications are discussed for when ignoring multilevel structure still provides a good approximation of multilevel confirmatory factor analysis (MCFA) results.

In many circumstances researchers collect data that have an internal multilevel structure. For example, researchers may collect questionnaires from students in different classrooms, participants in several states, or employees from many departments. In doing so, they often ignore the multilevel structure of data and use methods designed for single-level data. Julian (2001) showed that, when ignoring the macro level in CFA, parameter estimates including factor loadings, error variances, factor variances, and factor covariances are biased upward, leading to inflated Type I error such that correct models are rejected at more than the nominal level.

Although Julian (2001) revealed the biases of unstandardized parameter estimates, the effect of ignoring multilevel structure on standardized parameter estimates might be different. For example, when the factor correlation is equal across levels, ignoring the macro level should not change the factor correlation, which is similar to the lack of bias observed for regression coefficients in multilevel analysis when ignoring the macro level in the absence of a contextual effect (Moerbeek, 2004). The biases in standardized parameter estimates should be investigated because standardized coefficients are used more often than unstandardized coefficients in CFA (Floyd & Widaman, 1995). Therefore, the main purpose of this study is to investigate the effect of ignoring the macro level on standardized coefficients in CFA.

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Simulation Study

The purpose of this simulation study is to investigate bias in standardized factor loadings and factor correlations under various conditions.

Conditions

There are four conditions in this simulation study.

1. Sample Size (Groups/Group Size): 100/5, 10/50, 400/20, and 40/200.
2. Intraclass Correlation (ICC): .05, .15, .25, .50, and .75.
3. Macro-level Communalities: .75, .50, and .25.
4. Macro-level Factor Correlation: .2, .5, and .8.

Each condition was analyzed using1,000 replications.

Data Generation Model

We used a two-factor model in both the macro and micro levels. As shown in Figure 1, factor structures at both levels were the same. Factor loadings and item ICCs were fixed to be equal across items. We used intermediate phantom variables (the circles with black borders in Figure 1) to parameterize factor loadings as standardized factor loadings using nonlinear constraints. The factor loadings of observed variables on the phantom variables are equal to the product of item total standard deviation and either the square root of ICC for the macro level or the square root of 1 – ICC for the micro level.

Data Analysis Model

We analyzed the simulated data by two approaches: MCFA and single-level CFA by ignoring the macro level of multilevel data (i.e., disaggregated CFA). The intermediate phantom variable approach was also used in both analysis models. We used Mplus (Muthén & Muthén, 1998-2011) for data generation and data analysis. The target parameter estimates are the average of micro-level standardized factor loadings across items and the average of micro-level factor correlations.

Hypothesis

MCFA should provide unbiased parameter estimates. For the disaggregated CFA, we used Hägglund's (1982) noniterative estimation method for CFA and the equation partitioning total variance to micro and macro levels to find the expected biases in standardized parameter estimates. We found that:

1. The disaggregated standardized factor loadings were equal to the weighted average of standardized factor loadings across levels.
2. The disaggregated factor correlation was equal to the weighted average of factor correlations across levels.

The weights are dominated by ICC. The weights are given to macro level if ICC is higher.

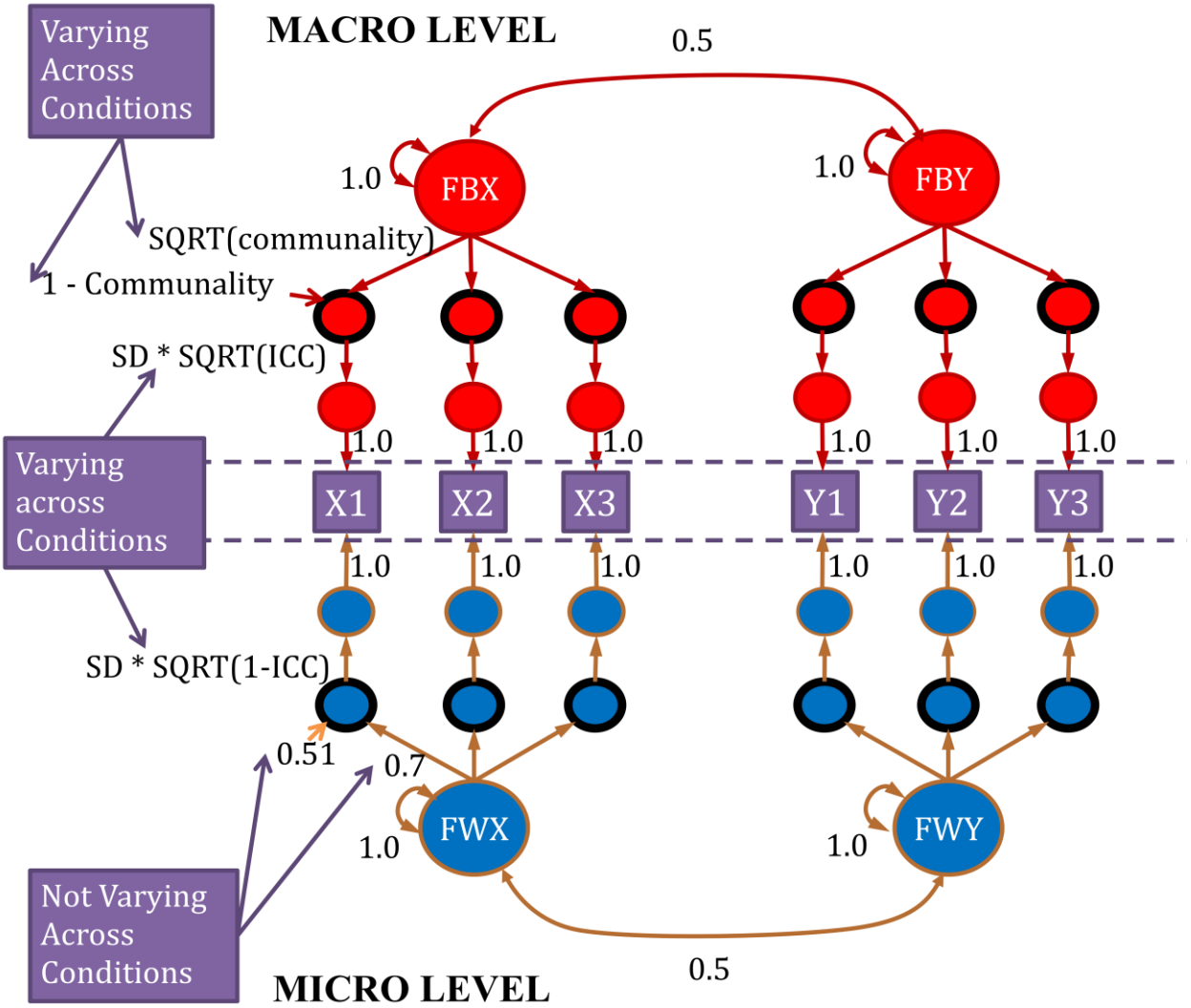

Figure 1. Data Generation Model.

Results

MCFA had lower convergence rates than the disaggregated CFA. We dropped all conditions for which the convergence rate was less than 10% (100 replications). The obtained standardized factor loadings were not affected by the factor correlation conditions and the obtained factor correlations were not affected by the standardized factor loading conditions. Therefore, for the sake of clarity, we collapsed the factor correlation conditions in the standardized factor loadings results interpretations and collapsed the standardized factor loading conditions in the factor correlation interpretations.

Figure 2 shows the average standardized factor loadings under various conditions analyzed by MCFA (blue lines) and the disaggregated CFA (red lines). MCFA provided unbiased parameter estimates such that the blue lines were close to 0.7, which was the parameter value for micro-level standardized factor loadings. For the disaggregated CFA, the obtained standardized loadings were higher in the high

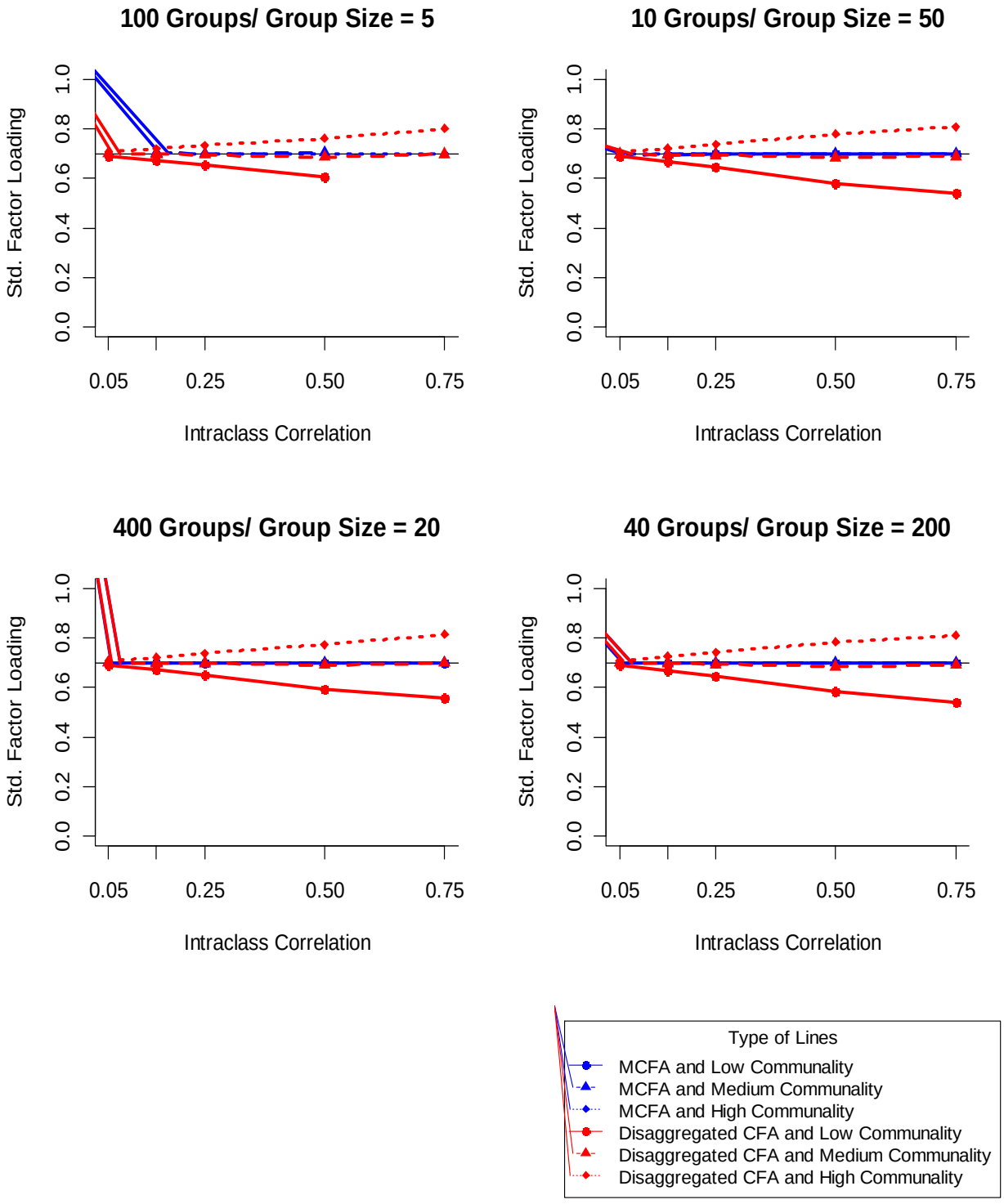

Figure 2. The average standardized factor loading obtained by multilevel confirmatory method (MCFA) and disaggregated single-level confirmatory factor analysis method in each condition of sample size, intraclass correlation, and communality.

macro-level standardized factor loading condition (dotted line), lower for the low conditions (solid line), and unbiased in the conditions for which the macro- and micro-level standardized factor loadings were equal (dashed line). The biases were higher when the ICC was higher.

Figure 3 shows that the obtained factor correlations analyzed by MCFA (blue line) were unbiased whereas the obtained factor correlations analyzed by the disaggregated CFA were biased. The direction of biases were similar to those for the standardized factor loadings such that the disaggregated factor correlations were equal to the weighted averages of the factor correlation parameters from both levels. The weights more heavily favored the macro level if the ICC was higher.

We also found that MCFA provided unbiased *SE* for factor correlations but overestimated the *SE* of standardized factor loadings. The disaggregated CFA provided equivalent standard errors to MCFA when the micro-level parameter estimates were unbiased. If the parameter estimates were overestimated, the standard errors were underestimated, and vice versa.

Discussion and Conclusion

The main purpose of this presentation is to investigate the effect of ignoring the macro level on standardized coefficients in CFA. We found that ignoring the macro level yielded unbiased standardized estimates when the parameters in both levels were equal even if ICC was high. The results were different from biases in unstandardized coefficients that were always biased, and the biases were stronger when ICC was larger (Julian, 2001). From this study, we may conclude that disaggregated standardized estimates were the weighted average (largely depending on ICC) of parameters in both levels.

In general, MCFA is highly recommended if the analysis converges. However, the results suggest that applied researchers might use single-level CFA and ignore the macro level when they are confident that the factor structure and standardized coefficients in the factor structure are equal across levels or when the ICCs are low (about .05).

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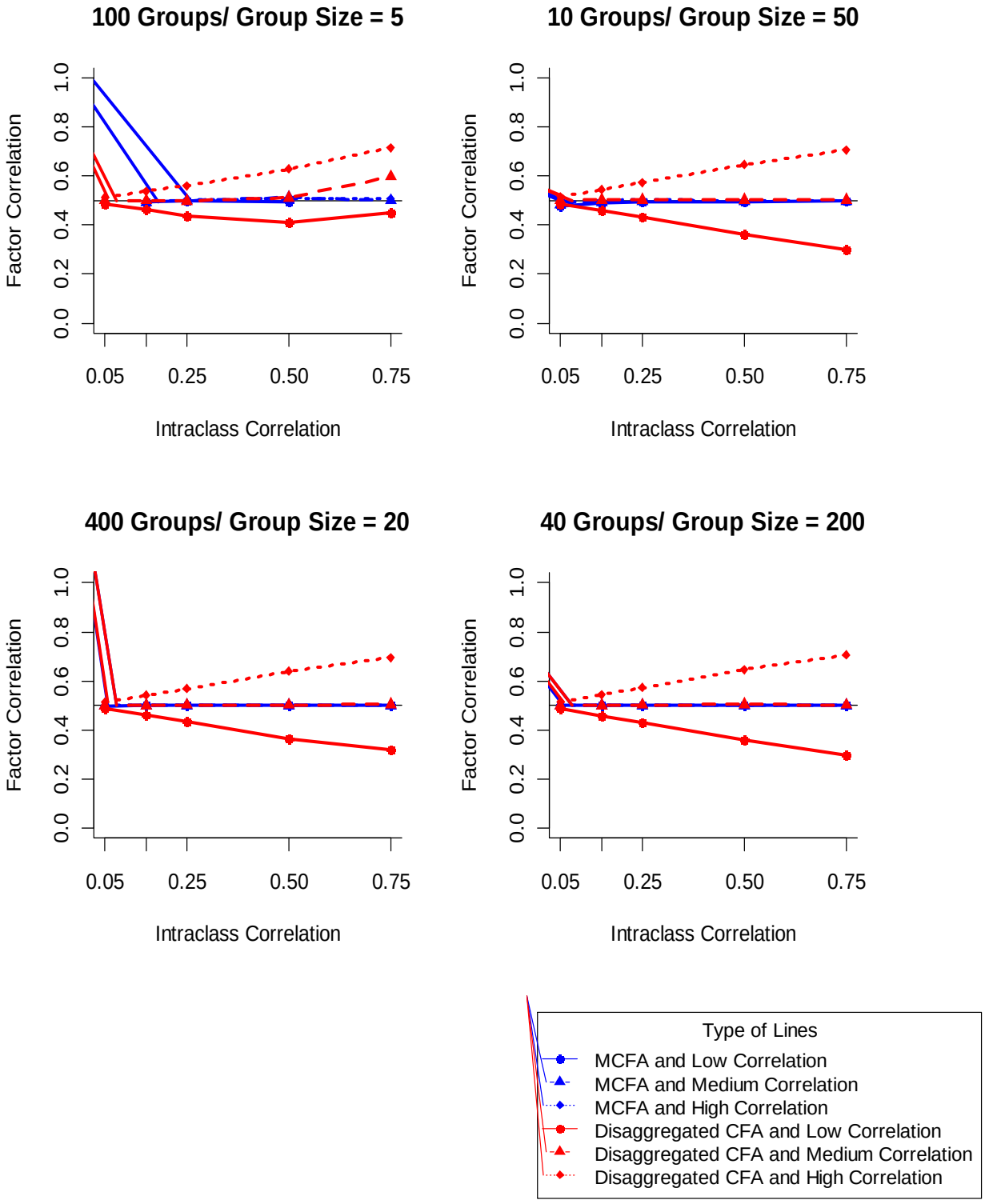

Figure 3. The average factor correlation obtained by multilevel confirmatory method (MCFA) and disaggregated single-level confirmatory factor analysis method in each condition of sample size, intraclass correlation, and communality.