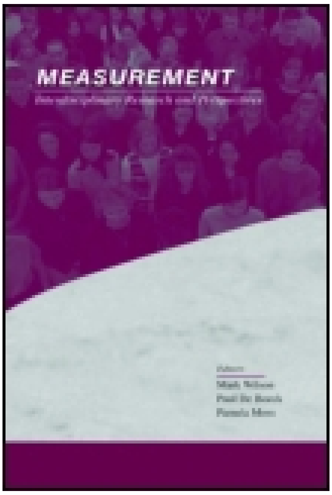

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Calling Models With Causal Indicators "Measurement Models" Implies More Than They Can Deliver

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Calling Models With Causal Indicators "Measurement Models" Implies More Than They Can Deliver

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We are delighted to see Bainter and Bollen's excellent paper as a focus article in *Measurement*. In our view, psychological researchers who use SEM rely too reflexively on reflective measurement, without sufficiently considering whether their indicators are likely to be caused by the latent construct. When causality flows from indicators to the construct, fitting a reflective model will result in model misfit, misspecification, incorrect parameter estimates, and fruitless discussion about the underlying factor structure of a questionnaire. This is a topic that requires greater awareness.

Bainter and Bollen defend the position that causal measurement is just as valid as reflective measurement and that it leads to no great interpretational problems. While we wholeheartedly agree that not all indicators should be treated as reflective, we find their position potentially misleading. The relation between causal indicators and the latent variable they indicate is insufficiently restrictive to allow causal indicators to uniquely pick out a latent variable. In fact, the identification of a latent variable as the target of a measurement instrument *requires effect indicators*. However, calling the causal indicator side of a model a "measurement model" implies that the causal model is in fact sufficient to identify a latent variable, obscuring the need for additional effect indicators. In our view, the debate over interpretational confounding is just one consequence of the ensuing confusion, and much would be gained by simply abandoning the terminology of measurement in discussing models with causal indicators.

CAUSAL INDICATORS DO NOT IDENTIFY CONSTRUCTS

Bainter and Bollen advocate a broad definition of measurement according to which any set of variables that share "conceptual unity" and "correspond to the meaning of the same concept" can be considered measures of a concept. Thus, a measurement model can consist of variables that are caused by the latent variable, variables that cause the latent variable, or perhaps variables

This is a commentary on the Focus Article, "Interpretational Confounding or Confounded Interpretations of Causal Indicators?" which published in issue 12(4) 2014 of *Measurement: Interdisciplinary Research & Perspectives*.

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that are otherwise "linked to" the latent variable.[1] This is perhaps the most liberal definition of measurement to date. In effect, Bainter and Bollen propose to call any operationalization a "measure" of a construct, regardless of what causes variation in the indicators used and the nature of the connection between construct and indicators.

Only a reflective measurement model (i.e., a set of effect indicators) carries a set of assumptions sufficiently restrictive to pick out a single latent variable. The reflective measurement model implies that effect indicators are *conditionally independent given the latent variable*. This property of the reflective measurement model is strong enough that the set of effect indicators alone can give us the variance of the latent variable as well as its covariance with its indicators and other variables in the model. Conceptually, effect indicators do this because they triangulate on their common cause: If the effect indicator model is true, the referents of the propositions "the latent variable represented in the effect indicators model" and "the common cause of systematic variation in the indicators" co-refer to the same entity. Causal indicators cannot triangulate in this way. Even if we were to have population data on *all* of the causal indicators of a latent variable, these causal indicators could be combined in an infinite number of ways to produce an infinite number of latent variables. Estimation of the causal indicator factor loadings and the latent variable (residual) variance requires an additional set of effect indicators. Effect indicators share only a single common cause, and thus only effect indicators allow the variance of a latent variable and its relations to other variables in the model (including causal indicators) to be uniquely identified.

Moreover, once the necessary set of effect indicators is in place, the causal indicators add no further information with respect to the identification of the latent variable. Bainter and Bollen's simulation showed that, when the reflective side of the measurement model is correctly specified, causal indicators are not subject to interpretational confounding. But their conclusion is far too weak. When the reflective side of the measurement model is correctly specified, causal indicators are *entirely superfluous* to the measurement and identification of the latent variable.[2] Of course, the paths from causal indicators to the latent variable may be of substantive interest, just as the predictive relations between covariates and the latent variable are of interest, but if the reflective side of the model is accurate, then the causal side of the model contributes nothing to the measurement of the latent variable.

DEPENDENT VARIABLES ARE NOT EFFECT INDICATORS

When the set of causal indicators loading on a latent variable is called a "measurement model," this nomenclature implies that the downstream part of the latent variable model (i.e., the relations between the latent variable and its effects) is part of the structural model. For example,

[1]This definition raises the intriguing possibility of other types of links. For example, we might conceive of "enjoyment of reading" as a *correlational indicator* of extraversion: More extraverted people tend to spend less time reading, but reading is neither a cause nor an effect of extraverted personality.

[2]The only way that causal indicators can affect the variance of the latent variable or its covariance with other variables in the model is if there is some misspecification in the relations between causal and effect indicators; in particular, if the variance shared among effect indicators (i.e., the latent variable) does not fully mediate the relations between each causal indicator and each effect indicator. Such misspecification can cause the reflective factor loading estimates to shift to account for the misspecification. When the model is correct, however, causal indicators can be removed from the model without affecting the latent variable.

in Bainter and Bollen's Figure 2, the paths connecting η_1 to η_2-η_5 are typically understood as structural paths. This appears to be the source of much of the confusion surrounding the causal indicator model. Causal "measurement" is not actually doing the work that is implied by calling it measurement (assuming the standard, everyday semantics of measurement). Causal measurement implies that, once the set of causal indicators is in place, we can go about estimating the structural relations between the causally identified latent variable and other constructs of interest. But this is not the case. In point of fact, if we follow this path, we are actually using those other constructs of interest to identify the latent variable. This runs counter to the standard way of thinking about research methodology, in which researchers typically assume that their indicator variables fix the referent of the latent variable.

To clarify the problem, we draw a distinction between effect indicators and dependent variables. This distinction is analogous to the distinction between covariates and causal indicators, except that it carries statistical as well as conceptual implications. As noted earlier, effect indicators are subject to the assumption of independence, conditional on the latent variable. Dependent variables, in contrast, are those variables that are hypothesized to be affected by the latent variable, but there is typically no reason that they would be independent conditional on the latent variable. Unlike effect indicators, dependent variables need not display conceptual unity, and they certainly do not need to be so closely related in meaning to the latent variable that the conditional independence assumption is plausible.

For example, suppose a researcher wants to know whether time spent in social interaction, as measured by time spent with friends, coworkers, family, and online social networks, affects friendship quality and subjective well-being (see Figure 1). The relation between interpersonal relations and the two dependent variables is not known a priori—they may be related or they may not be—after all, that's the research question. Subjective well-being and friendship quality are not *measures* of interpersonal relationships in Bainter and Bollen's sense of displaying conceptual unity with the concept. To identify the model, however, the researcher is forced to impose the assumption that the dependent variables are independent conditional on interpersonal relationships; that is, the researcher is forced to treat these dependent variables as effect indicators,

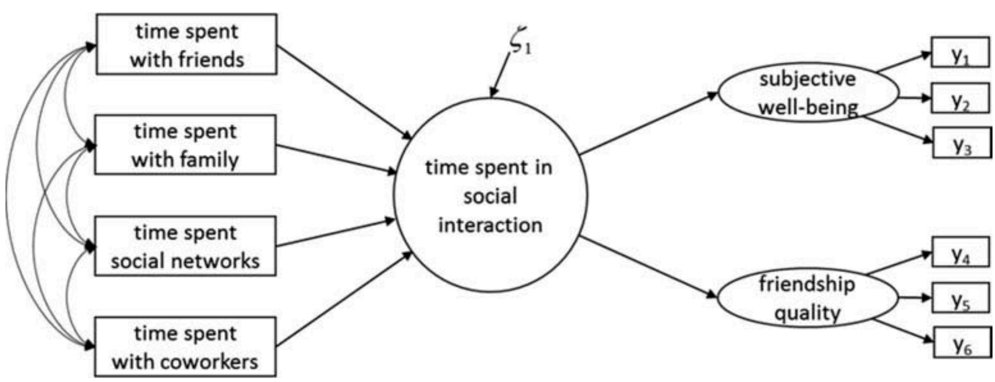

FIGURE 1 This model is only correctly specified if subjective well-being and friendship quality are independent conditional on time spent in social interaction.

because *effect indicators are required for measurement of the latent variable*. The "measurement model" label, applied to causal indicators, thereby creates the misconception that the causal indicators are doing the measurement job in the model, while the remainder of the model can be interpreted as a set of structural relations. This is clearly mistaken.

Interpretational confounding arises because researchers treat dependent variables as effect indicators—by forcing them to be conditionally independent given the latent variable—in order to identify the model. Imposing the conditional independence assumption forces the latent variable to represent the source of shared variance among a set of dependent variables. The meaning of the latent variable thus identified can be a far cry from what was intended, which is something like "whatever construct is closest in meaning to the set of causal indicators."

Bainter and Bollen showed that interpretational confounding arises only in models that are not correctly specified. They are right. But interpretational confounding will continue to arise in causal models because the need for true effect indicators—those that satisfy the conditional independence assumption—in addition to causal indicators and dependent variables, is not well understood.

CONCLUSION

Bainter and Bollen have done the psychometric community a great service in elucidating the role of correct model specification in thinking about interpretational confounding. However, despite the appropriate emphasis on correctly specified models, Bainter and Bollen overreach in requiring causal indicators to measure or identify a latent variable. Causal indicators cannot, by themselves, identify latent variables without a set of effect indicators, and given a set of effect indicators they are superfluous in determining the meaning of the latent variable in the model. Causal indicators are not measures of their common effect, and to treat them as such is to court conceptual confusion.

Measurement is an important way of operationalizing constructs, but it is not the only way. For example, for many questionnaires it is common to form composite scores according to a fixed weighting scheme. This of course does not allow for interpretational confounding, because the weights are not identified through the fit of a reflective latent variable model. In this sense, we may consider composites to escape some of the problems that plague causal indicators. But of course nobody would claim that indicator variables "measure" the composite they form. And that is exactly as it should be.

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