

Why Never to Use PROCESS Model 14 for Moderated Mediation Analysis

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Abstract

A common approach for testing a moderated mediation with a moderated b-path is model template 14 from Hayes' PROCESS macro for SPSS or for R. This model template can lead to seriously biased results which is explicated using simulated datasets. Alternatives to using model 14 are shown.

KEYWORDS: MODERATED MEDIATION, PROCESS MACRO

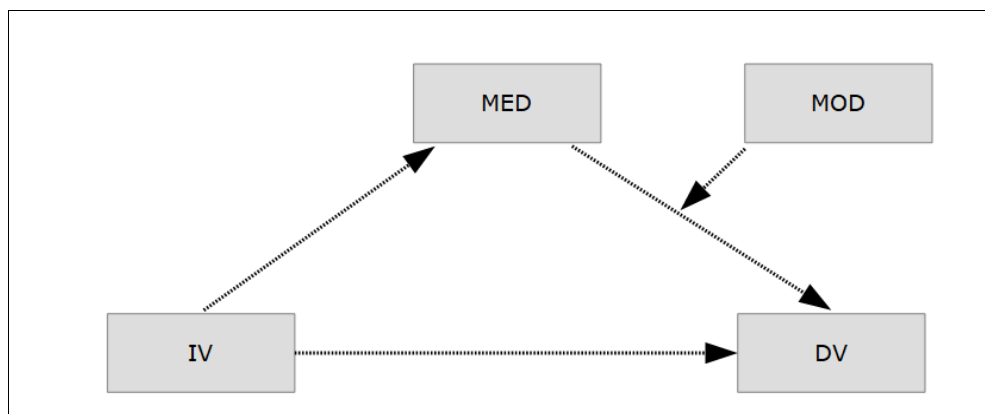
1. Introduction

For quite some time one of the most popular ways for testing moderated mediation models (i. e. combinations of moderation and mediation) has been Hayes' PROCESS macro (Hayes, n.d.) for SPSS or R.

One popular model, model template 14, is a moderated mediation with a moderated b-path (from mediator to dependent variable) but without a moderated c'-path (from independent variable to dependent variable), see figure 1.

Figure 1

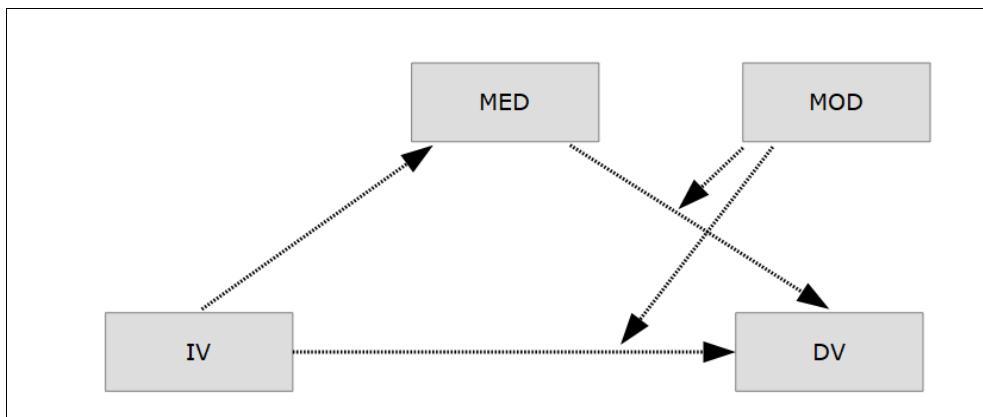
PROCESS Model Template 14



Note. Adapted from Hayes (2018).

Many PROCESS models come in pairs, so there is also a similar model with a moderated b-path and a moderated c'-path, PROCESS model 15, see figure 2.

A search conducted 9/25/2022 on Google Scholar with the search strings "*model 14*" hayes process and "*model 15*" hayes process gave 6,260 hits (model 14) and 5,140 hits (model 15) respectively, so there is a lot of research based on these models.

Figure 2*PROCESS Model Template 15*

Note. Adapted from Hayes (2018).

However, statistical methods have assumptions, and if those are not met, then the results can be seriously biased and misleading. PROCESS is based on regression analyses, therefore the assumptions for linear regression models are relevant here. There are several different sets of assumptions put forth in the literature. Those have to be tested if you want to report PROCESS results (Regorz, 2020); however, for some assumptions you could use robust techniques (e.g. bootstrapping, robust standard errors) instead of testing the assumptions.

But one crucial regression assumption is often overlooked: We have to test the correct model (absence of specification bias, Gujarati, 2004). Otherwise the results can be massively biased.

If we want to use PROCESS model 14, then our theory is that the b-path of a mediation is moderated but the c'-path is not. But we can't be sure of that. It is possible that, contrary to our expectation, b-path and c'-path are both moderated, or only the c'-path. If we run statistical tests, then we must make sure that the results are not only correct when our theory holds but also when our theory does not hold. If we were certain beyond any reasonable doubt about the true relationship in the population, then we had no reason to run statistical tests in the first place.

Therefore we need a testing strategy that can handle all three possible cases: A moderated b-path, a moderated b-path and c'-path, and a moderated c'-path only. The next section will show that model 14 cannot provide for that.

2. Why Can PROCESS Model 14 Lead to False Results?

If we have a moderation of the c'-path but not of the b-path, then we have an overall moderation in our data. But since we don't allow for a moderation of the c'-path in model 14 this moderation manifests itself in the only place where it can show itself: in the interaction for the b-path.

And since the index of moderated mediation for model 14 is in parts based on the interaction of the b-path the same bias will result in the index of moderated mediation.

3. Simulation Analysis

In order to show that model 14 cannot really distinguish between a moderation of the b-path and a moderation of the c'-path, I ran a simulation analysis. I randomly produced three different samples: One sample based on a mediation where only the b-path was moderated, one sample where the b-path and the c'-path were moderated, and one sample where only the c'-path was moderated.

For each of those samples I ran PROCESS model 14 and PROCESS model 15. The results are shown below. (It is not possible to compare the three simulations to each other – the relevant comparisons are within each simulation between the results for model 14 and model 15).

Moderated b-Path Only (True Model is Model 14)

In the population for this simulated dataset there was only a moderated b-path, no moderated c'-path.

Based on model 14 the interaction for the b-path was significant, $b = 0.321$, $p < .001$. The index of moderated mediation was significant, too, 0.106, 95% percentile CI [0.072, 0.142].

Based on model 15 the interaction for the b-path was significant, $b = 0.320$, $p < .001$. The index of moderated mediation was significant, too, 0.106, 95% percentile CI [0.069, 0.144].

So, for the population with only a moderated b-path both model templates 14 and 15 lead to almost exactly the same results.

Moderated b-Path and Moderated c'-Path (True Model is Model 15)

In the population for this simulated dataset there was a moderated b-path and a moderated c'-path.

Based on model 14 the interaction for the b-path was significant, $b = 0.176$, $p < .001$. The index of moderated mediation was significant, too, 0.052, 95% percentile CI [0.024, 0.088].

Based on model 15 the interaction for the b-path was significant, $b = 0.099$, $p = .039$. The index of moderated mediation was significant, too, 0.029, 95% percentile CI [0.003, 0.059].

For this population with a moderated b-path and a c'-path model template 14 gave a widely inflated estimate for the moderation of the b-path and for the index of moderated mediation compared to the true model 15. (The bias for the b-path doesn't always lead to an increase of the estimate of the interaction term compared to its true value. If the [true, population based] interactions for b-path and c'-path have different signs it should be possible that the bias for the b-path leads to a decrease in the estimate for the interaction term if model 14 is used instead of model 15.)

Moderated c'-Path Only (True Model is Model 5)

In the population for this simulated dataset there was a moderated c'-path but no moderated b-path.

Based on model 14 the interaction for the b-path was significant, $b = 0.090$, $p = .043$. The index of moderated mediation was significant, too, 0.041 , 95% percentile CI $[0.003, 0.082]$.

Based on model 15 the interaction for the b-path was not significant, $b = 0.003$, $p = .960$. The index of moderated mediation was not significant, 0.001 , 95% percentile CI $[-0.047, 0.044]$.

For this population with a moderated c'-path and no moderated b-path the model template 14 falsely gave a significant b-path and falsely gave a significant index of moderated mediation while model template 15 correctly showed that there was no moderation of the b-path (but a significant moderation of the c'-path) and no significant index of moderated mediation.

Conclusions From the Simulation Analysis

The simulation results show that PROCESS model 14 is not very helpful to test a moderated mediation. A significant model 14 can be the results of a mediation model with a moderated b-path, of a mediation model with both moderated b-path and c'-path, and of a mediation model with a moderated c'-path only. Basing any conclusion on model 14 can lead to completely false results.

What the simulation results show, too, is that model 15 lead to correct conclusions in all three cases.

4. Recommendations

You can find the main recommendation in the title of this paper: Don't use PROCESS model 14.

If you want to use PROCESS to test a moderated mediation with a moderated b-path, then use model 15 instead of model 14. Because then it does not matter whether the b-path, the c'-path, or both are moderated.

If you know a little bit more about the different moderated mediation models implemented with PROCESS, then you may have realized that this problem is not confined to model 14. There are many other model templates with a moderated b-path but without a moderation of the c'-path. All those model templates are suspect, too.

As with process models 14 and 15 those other models often come in pairs. For each model with a moderated b-path but without a moderated c'-path you will find a similar model with the same paths but with an additional moderation for the c'-path. In order to be safe, you should use those similar models.

Or, as a general recommendation:

Only use process models with a moderated b-path that also contain a moderated c'-path.

Table 1 shows you some of the moderated mediation models with a moderated b-path that should not be used and the alternative models you could use instead.

When it comes to published research you should be highly suspicious of results that have been obtained by using PROCESS model 14 (and 16, 18, 21, 22, 58). As long as they have not been replicated by other means those results are in need of a replication with a correct method.

Replication with the same model template (e.g., model 14) does not help because then the bias can be replicated, too.

Table 1

Problematic PROCESS Models for Moderated Mediation

Problematic model	Better alternative
Model 14	Model 15
Model 16	Model 17
Model 18	Model 19
Model 21	Model 28
Model 22	Model 29
Model 58	Model 59
Model 5 ^a	Model 15

Note. In addition to the model templates in the table there are some presumably more rarely used models in the 60+ range. For those, please use the generic advice to always include a moderated c'-path for models with a moderated b-path.

^a Model 5 is not a moderated mediation but a mediation model with a moderated direct effect.

References

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Simulation data

Here is an file with the data I simulated for this tutorial:

http://www.regorz-statistik.de/en/sim_data_never_model_14.xls

Citation

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http://www.regorz-statistik.de/en/never_use_process_model_14.pdf

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