



Background

- Mediation analysis is important to psychology because it explains mechanism of cause, and offers a point of intervention
- The simplest mediation model, cross-sectional mediation, is almost always biased when the underlying true model is longitudinal or random, and the extent of the bias in large part depends on the relative stabilities of X and M^{1,2}
- However, specifying a correct longitudinal model can be difficult and may not be worth the additional time and money necessary to collect appropriate data
 - "Normally the lag between measurements is chosen because of convenience, not theory, since theory rarely specifies the exact length of the causal lag"³
 - Without knowing the appropriate time lag between effects, three time points may not be sufficient⁴
 - The influence that a variable exerts on another variable may change over time⁵

Motivating Questions:

- Using the same amount of data, how well can simpler and sometimes misspecified models perform, using power and type I error rate as criteria?
- How are they impacted by: between-person variance, stability of variables over time, and inappropriate lag time between measurements?
- When is it necessary to use a more complex model?

Simulation Design

- ✤ 500 data sets of 100 people × 100 time points generated for each condition under MM and MLM
- A subset of 100 data points per variable used for each analysis under CSM, SM, DM, and CLPM models, or the full data set is used for MM and MLM analysis
- Mediation is tested using the Sobel test on the indirect path, $\frac{\hat{a}\hat{b}}{\sqrt{\hat{b}^2\hat{s}_a^2 + \hat{a}^2\hat{s}_b^2}} \sim N(0,1)$
- * a, b, c = 0, 0.36
- ◆ *y* = 0.36
- Stability of X, M = 0, 0.36
- Level-2 error variance = 0, 0.0025, 0.01, 0.0225
- Total variance of X, M, Y = 1

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0.36

Power: Between-person variance = 0, Lag = 1 (Generated under MLM)

Path C 0.36

Time and Other Considerations in Mediation Design Meghan K. Cain & Zhiyong Johnny Zhang **Department of Psychology, University of Notre Dame**

All models were specified in MPlus

Generating Models: Multilevel Mediation (MM) and Multilevel Longitudinal Mediation (MLM) * Test Models: Cross-Sectional Mediation (CSM), Sequential Mediation (SM), Dynamic Mediation (DM), and Cross-Lagged Panel Mediation with 3 (CLPM3) or 5 time points (CLPM5)





Dynamic Mediation

100 time points, 1 person

3 time points, 33 people OR 5 time points, 20 people

• Each has the same path diagram as MLM, except in regard to the number of time points and people

			Resu	ts:	lissp	Decifi	ed La	g			
W	wer: Between-person variance = 0, Lag = 0 (Generated under MM)										
1	Stabil	ity				Model					
	Х	Μ	CSM	SM	DM	CLPM3	CLPM5	MM	MLM		
	0.5	0.5	0.99	0.76	0.04	0.02	0.04	0.99	0.92		
	0.36	0.36	0.93	0.35	0.01	0.01	0.01	1.00	0.85		
	0.36	0.5	0.96	0.67	0.04	0.01	0.02	0.99	0.88		
	0.5	0.36	0.96	0.43	0.02	0.01	0.01	1.00	0.87		
-	0.5	0.5	1	0.95	0.11	0.04	0.03	1	0.97		
	0.36	0.36	0.98	0.58	0.02	0.01	0.01	1	0.94		
)	0.36	0.5	0.99	0.85	0.05	0.01	0.03	1	0.97		
	0.5	0.36	0.98	0.7	0.04	0.02	0.02	1	0.97		

1	Stability					Model			
	Х	Μ	CSM	SM	DM	CLPM3	CLPM5	MM	MLM
	0.5	0.5	0.20	0.98	0.94	0.47	0.73	0.99	0.97
	0.36	0.36	0.01	0.94	0.92	0.46	0.69	0.98	0.96
	0.36	0.5	0.09	0.97	0.94	0.46	0.72	0.98	0.96
	0.5	0.36	0.07	0.95	0.92	0.38	0.65	0.98	0.96
	0.5	0.5	0.54	1	0.98	0.62	0.86	0.95	1
	0.36	0.36	0.18	0.96	0.97	0.56	0.79	0.97	1
	0.36	0.5	0.28	0.99	0.98	0.58	0.85	0.97	1
	0.5	0.36	0.34	0.99	0.97	0.55	0.81	0.97	1

REFERENCES

¹Maxwell, S. E., & Cole, D. A. (2007). Bias in cross-sectional analyses of longitudinal mediation. Psychological methods, 12(1), 23. ²Maxwell, S. E., Cole, D. A., & Mitchell, M. A. (2011). Bias in cross-sectional analyses of longitudinal mediation: Partial and complete mediation under an autoregressive model. Multivariate Behavioral Research, 46(5), 816-841.

³Kenny, D. A. (1975). Cross-lagged panel correlation: A test for spuriousness. Psychological Bulletin, 82(6), 887. ⁴Gollob, H. F., & Reichardt, C. S. (1987). Taking account of time lags in causal models. Child development, 80-92. ⁵Reichardt, C. S. (2011). Commentary: Are three waves of data sufficient for assessing mediation?. Multivariate behavioral research, 46(5), 842-851.

Models



	Model								
BPvar	CSM	SM	DM	CLPM3	CLPM5	MM	MLM		
0	0.03	0.02	0.03	0.00	0.04	0.04	0.00		
0.0025	0.03	0.03	0.05	0.01	0.03	0.03	0.01		
0.01	0.03	0.05	0.13	0.03	0.05	0.04	0.02		
0.0225	0.08	0.10	0.22	0.02	0.05	0.04	0.03		

Power: Lag specified correctly, Stability of X = M = 0.50, a = b = 0.36

Path		Model								
C	BPvar	CSM	SM	DM	CLPM3	CLPM5	MM	MLM		
	0	0.99	0.98	0.94	0.47	0.73	0.99	0.97		
\cap	0.0025	0.97	0.98	0.89	0.48	0.74	0.99	0.96		
0	0.01	0.98	0.99	0.83	0.45	0.71	1.00	0.95		
	0.0225	0.97	0.97	0.71	0.46	0.71	0.99	0.99		
	0	1.00	1.00	0.98	0.62	0.86	1.00	1.00		
26	0.0025	1.00	0.99	0.97	0.60	0.87	0.99	1.00		
.30	0.01	1.00	1.00	0.90	0.60	0.85	1.00	1.00		
	0.0225	0.99	0.99	0.80	0.56	0.81	0.99	1.00		

Power is higher under partial mediation

Cross-lagged panel was underpowered throughout.

- expect population to fall within $\sim .15$ range on mediation path coefficients
- mediation. Future work could explore under what conditions these models fall apart
- find the effect while maintaining type I error
- same level of power





Results: Individual Differences

Type 1 error rate: Lag specified correctly, Stability of X = M = 0.50, a = c = 0, b = 0.36

Conclusions

• Dynamic mediation was most affected by increases in between-person variance, only acceptable to use if

* Sequential performed well under misspecified lag when M was highly stable, and cross-sectional

performed next best when both X and M were highly stable, both performing better under partial

• When lag is misspecified and X and M are unstable, MLM may be required and is preferred over MM to

• Future work could explore how many people/time points are needed for each model to achieve the