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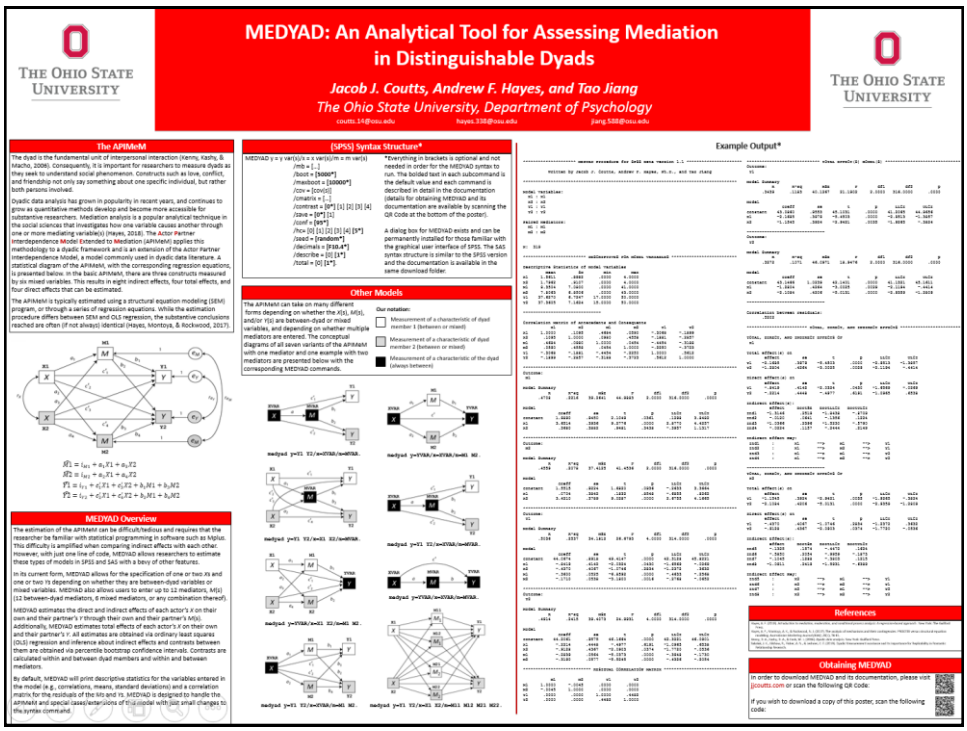
Easy Statistical Mediation Analysis with Distinguishable Dyadic Data

Andrew F. Hayes

Ohio State University

in collaboration with Jacob J. Coutts and Tao Jiang

APS convention, Washington DC, 25 May 2019



Dyads

Interpersonal relationships and interactions are crucial in people's lives.

Dyad is the most basic unit of interpersonal relationships and interactions.

- married or dating couples
- friends
- parent and child
- patient and caregiver
- coworkers

Many social phenomena are dyadic in nature.

- Conflict
- Love
- Social support

Many theories in social and behavioral science are about dyadic interactions.

- Social exchange theory
- Interdependence theory
- Attachment theory

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Assessing Mediation in Dyadic Data Using the Actor-Partner Interdependence Model

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The assessment of mediation in dyadic data is an important issue if researchers are to test process models. Using an extended version of the actor-partner interdependence model the estimation and testing of mediation is complex, especially when dyad members are distinguishable (e.g., heterosexual couples).We show how the complexity of the model can be reduced by assuming specific dyadic patterns. Using structural equation modeling, we demonstrate how specific mediating effects and contrasts among effects can be tested by phantom models that permit point and bootstrap interval estimates. We illustrate the assessment of mediation and the strategies to simplify the model using data from heterosexual couples.

Keywords: mediation, dyadic data, APIM, phantom models, bootstrapping

Models of mediation are common and of great importance, as they can provide information about causal relationships between variables that are mediated by one or more sets of intervening variables. Mediation refers to a mechanism through which an initial (X) influences an outcome (Y) by a third variable (M), termed *mediator* or *intervening* variable (Baron & Kenny, 1986; Judd & Kenny, 1981). In this mediation model, the effect from X to M is commonly designated as a, the effect from M on Y as b, and the effect from X on Y as c' (MacKinnon, 2008). The mediating or indirect effect (IE) of X on Y equals ab and the total effect equals $ab + c'$.

Over the last decade, researchers have begun to examine mediating mechanisms in dyadic data. The most commonly used model for this purpose is the actor-partner interdependence

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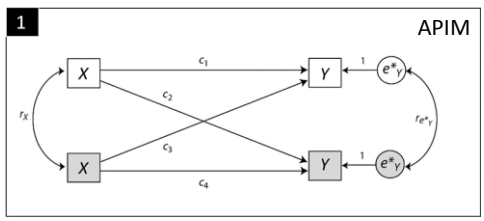
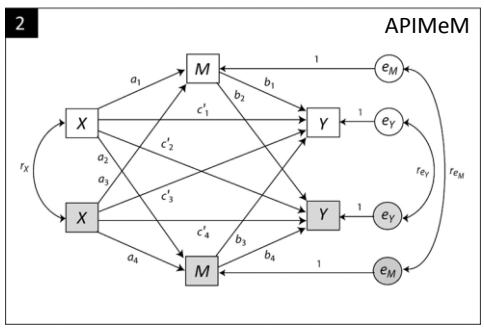
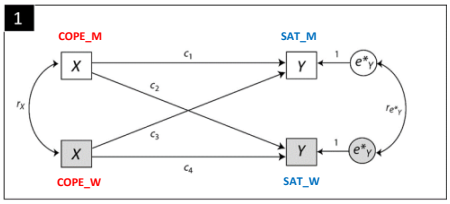


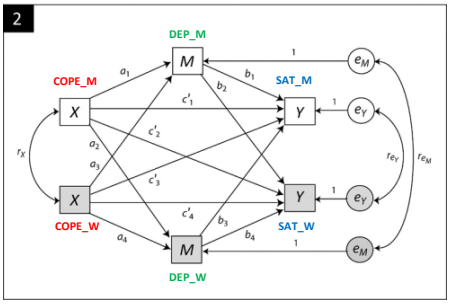


Ledermann et al (2011) discuss these model for distinguishable and indistinguishable dyad members. Here, I focus only on distinguishable dyad members.

Example

- Data from the 500 Family Study (PIs: Barbara Schneider and Linda Waite)
- A study of husbands and wives
  - 319 heterosexual couples
- Coping (*X*) - Feeling of cannot cope with everything (higher = more inability to cope)
  - COPE_M – Man (Husband)
  - COPE_W – Woman (Wife)
- Depression (*M*) - CES–D
  - DEP_M – Man (Husband)
  - DEP_W – Woman (Wife)
- Marital Satisfaction (*Y*) - (15 items of the ENRICH marital inventory)
  - SAT_M – Man (Husband)
  - SAT_W – Woman (Wife)





I reserve judgment on whether this is substantively interesting. It is the example used in Ledermann et al. (2011). I ignore worries about causal inference from correlational data. That's another talk. This kind of design and analysis is commonplace.

The data

A data file to be used in a dyadic data analysis must be in the proper form, depending on the type of analysis being conducted. For this analysis, the data are in "dyad structure" form. Each row is a dyad. Columns are variables measured on one or both dyad members.

FAMID__1	COPE_W	DEP_W	SAT_W	COPE_M	DEP_M	SAT_M
1001	2	7	39	1	5	41
1002	0	3	36	2	4	39
1003	2	2	46	1	4	49
1004	3	27	31	2	7	34
1005	4	31	37	2	11	35
1006	3	7	27	2	13	38
1008	3	10	34	2	5	39
1009	1	2	45	0	1	49
1010	2	10	42	1	3	35
1011	1	14	43	2	7	38
1012	1	9	50	1	12	48
1014	2	9	39	1	2	40
1016	2	0	38	0	3	47
1017	2	6	37	1	5	31
1018	2	2	36	1	14	33
1020	1	3	44	1	5	36

Typical analytical approach

SEM is most typically used, though there is lots of variation in implementation

An Mplus program to do the analysis:

```
ANALYSIS:
  !BOOTSTRAP = 5000;
MODEL:
  DEP_M ON COPE_M COPE_W;
  DEP_W ON COPE_M COPE_W;
  SAT_M ON DEP_M DEP_W COPE_M COPE_W;
  SAT_W ON DEP_M DEP_W COPE_M COPE_W;
  COPE_M WITH COPE_W;
  DEP_M WITH DEP_W;
  SAT_M WITH SAT_W;
MODEL INDIRECT:
  SAT_M IND COPE_M;
  SAT_W IND COPE_M;
  SAT_W IND COPE_W;
  SAT_M IND COPE_W;
OUTPUT:
  !CINTERVAL(BOOTSTRAP);
```

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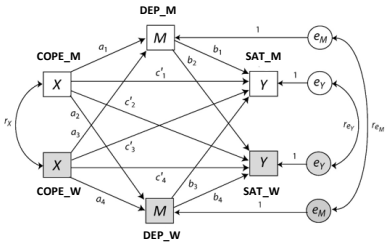


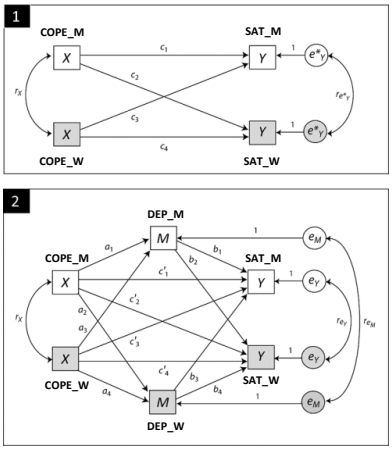
This would be executed twice, once without bootstrapping to get model paths and standard errors and once with to get bootstrap confidence intervals for indirect effects.

Making it easier: MEDYAD

Pronounced ***Meh'***-die-add or Meh-***die'***-add

- An observed variable path analysis tool for SPSS and SAS.
- Can estimate the APIM and APIMeM and variations.
- **Only a single line of code conducts the analysis**, regardless of how complex the model.
- **Generates the same results you get when using an SEM program.**
- Estimates path coefficients using OLS regression.
- Inference about indirect effects through percentile bootstrap confidence intervals.
- Conducts contrasts of indirect effects.
- Many other features.
- Freely available.

MEDYAD code



In SPSS:

```
MEDYAD Y=SAT_M SAT_W/M=DEP_M DEP_W/X=COPE_M COPE_W.
```

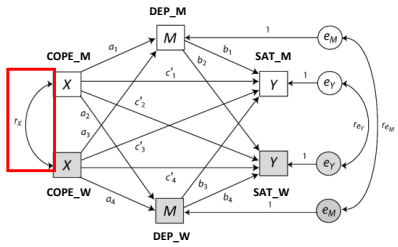
In SAS:

```
%MEDYAD (DATA=COUPLES,Y=SAT_M SAT_W,M=DEP_M DEP_W,X=COPE_M COPE_W);
```

That's it!

MEDYAD output

```
Model Variables:
  X1 : COPE_M
  X2 : COPE_W
  Y1 : SAT_M
  Y2 : SAT_W

Paired Mediators:
  M1 : DEP_M
  M2 : DEP_W


N:      319
Seed:  5000

************************ DESCRIPTIVES FOR MODEL VARIABLES *************************

Descriptive Statistics of Model Variables
             Mean          SD         Min         Max
COPE_M     1.5611       .8982       .0000      4.0000
COPE_W     1.7962       .9107       .0000      4.0000
DEP_M      8.3504      7.0800       .0000     41.0000
DEP_W      7.8063      6.8506       .0000     43.0000
SAT_M     37.6270      6.7247     17.0000     50.0000
SAT_W     37.3605      7.1624     15.0000     50.0000

-------------------------------

Correlation Matrix of Antecedents and Consequents
          COPE_M     COPE_W      DEP_M      DEP_W      SAT_M      SAT_W
COPE_M    1.0000      .1095      .4684      .0590     -.3068     -.1899
COPE_W     .1095     1.0000      .0980      .4558     -.1881     -.2857
DEP_M      .4684      .0980     1.0000      .0454     -.4454     -.3188
DEP_W      .0590      .4558      .0454     1.0000     -.2250     -.3723
SAT_M     -.3068     -.1881     -.4454     -.2250     1.0000      .5612
SAT_W     -.1899     -.2857     -.3188     -.3723      .5612     1.0000
```

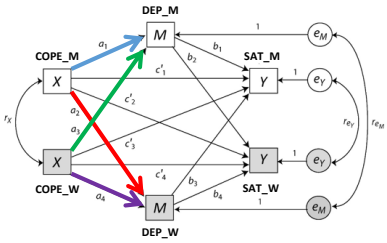


Simple correlations between couples' inability to cope, depression, and marital satisfaction.

MEDYAD output

(first stage effects)

Actor and partner effects of inability to cope on depression.

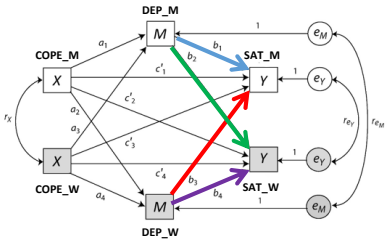



```
**************************************************
Outcome:
 DEP_M

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .4708      .2216    39.2641    44.9883     2.0000   316.0000     .0000

Model
             coeff         se          t          p       LLCI       ULCI
constant    1.9890      .9450     2.1049     .0361      .1298     3.8482
COPE_M      3.6514      .3936     9.2776     .0000     2.8770     4.4257
COPE_W       .3680      .3882      .9481     .3438     -.3957     1.1317

*****************************************************************************
Outcome:
 DEP_W

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .4559      .2078    37.4125    41.4536     2.0000   316.0000     .0000

Model
             coeff         se          t          p       LLCI       ULCI
constant    1.5515      .9224     1.6820     .0936     -.2633     3.3664
COPE_M       .0704      .3842      .1832     .8548     -.6855      .8262
COPE_W      3.4210      .3789     9.0287     .0000     2.6755     4.1665

*****************************************************************************
```

MEDYAD output

(second stage effects)

Actor and partner effects of depression on marital satisfaction

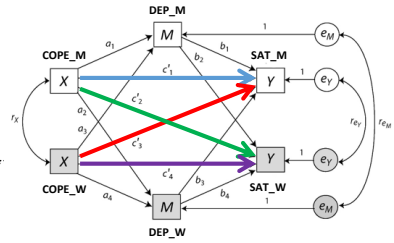



```
**************************************************
Outcome:
 SAT_M

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .5036      .2537    34.1812    26.6793     4.0000   314.0000     .0000

Model
             coeff         se          t          p       LLCI       ULCI
constant   44.0674      .8918    49.4147     .0000    42.3128    45.8221
COPE_M      -.8419      .4142    -2.0324     .0430    -1.6569     -.0269
COPE_W      -.4370      .4067    -1.0746     .2834    -1.2372      .3632
DEP_M       -.3600      .0525    -6.8592     .0000     -.4633     -.2568
DEP_W       -.1710      .0538    -3.1800     .0016     -.2768     -.0652

*****************************************************************************
Outcome:
 SAT_W

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .4914      .2415    39.4073    24.9931     4.0000   314.0000     .0000

Model
             coeff         se          t          p       LLCI       ULCI
constant   44.2061      .9575    46.1664     .0000    42.3221    46.0901
COPE_M      -.2214      .4448     -.4977     .6191    -1.0965      .6538
COPE_W      -.9128      .4367    -2.0903     .0374    -1.7720     -.0536
DEP_M       -.2839      .0564    -5.0373     .0000     -.3948     -.1730
DEP_W       -.3190      .0577    -5.5245     .0000     -.4326     -.2054
```

MEDYAD output

(direct effects)

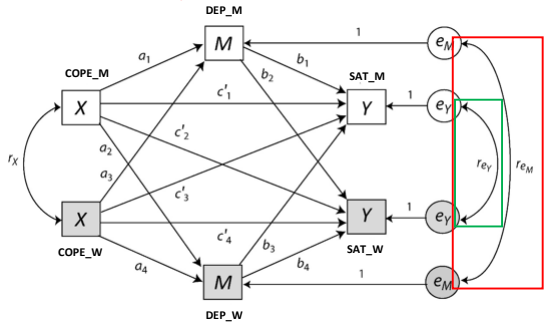
Actor and partner direct effects of inability to cope on marital satisfaction




```
**************************************************
Outcome:
 SAT_M

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .5036      .2537    34.1812    26.6793     4.0000   314.0000     .0000

Model
              coeff         se          t          p       LLCI       ULCI
constant    44.0674      .8918    49.4147     .0000    42.3128    45.8221
COPE_M       -.8419      .4142    -2.0324     .0430    -1.6569    -.0269
COPE_W       -.4370      .4067    -1.0746     .2834    -1.2372     .3632
DEP_M        -.3600      .0525    -6.8592     .0000     -.4633     -.2568
DEP_W        -.1710      .0538    -3.1800     .0016     -.2768     -.0652

*****************************************************************************
Outcome:
 SAT_W

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .4914      .2415    39.4073    24.9931     4.0000   314.0000     .0000

Model
              coeff         se          t          p       LLCI       ULCI
constant    44.2061      .9575    46.1664     .0000    42.3221    46.0901
COPE_M       -.2214      .4448     -.4977     .6191    -1.0965     .6538
COPE_W       -.9128      .4367    -2.0903     .0374    -1.7720    -.0536
DEP_M        -.2839      .0564    -5.0373     .0000     -.3948     -.1730
DEP_W        -.3190      .0577    -5.5245     .0000     -.4326     -.2054
```

MEDYAD output

(residual, i.e, partial correlations)



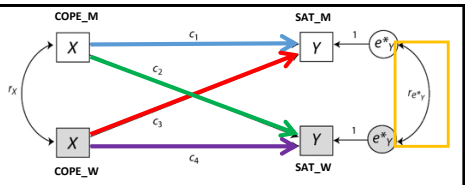

```
************************** RESIDUAL CORRELATION MATRIX ****************************

          DEP_M     DEP_W     SAT_M     SAT_W
DEP_M    1.0000    -.0045     .0000     .0000
DEP_W    -.0045    1.0000     .0000     .0000
SAT_M     .0000     .0000    1.0000     .4482
SAT_W     .0000     .0000     .4482    1.0000
```

Correlation between spouses' depression controlling for inability to cope, and correlation between spouses' marital satisfaction controlling for inability to cope and depression.

MEDYAD output

(APIM: total effects)

Actor and partner total effects of inability to cope on marital satisfaction.

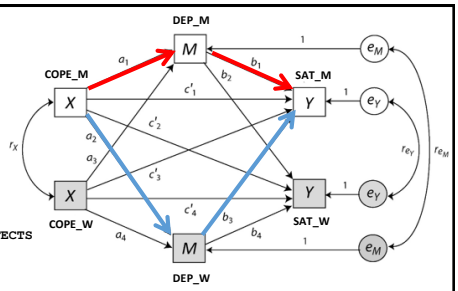



```
***************************** TOTAL EFFECT(S) MODEL(S) ******************************
Outcome:
 SAT_M

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3439      .1183    40.1267    21.1902     2.0000   316.0000      .0000

Model
                coeff         se          t          p       LLCI       ULCI
constant     43.0860       .9553    45.1031     .0000    41.2065    44.9656
COPE_M       -2.1685       .3979    -5.4503     .0000    -2.9513    -1.3857
COPE_W       -1.1545       .3924    -2.9421     .0035    -1.9265     -.3824

------------------------------
Outcome:
 SAT_W

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .3272      .1071    46.0971    18.9476     2.0000   316.0000      .0000

Model
                coeff         se          t          p       LLCI       ULCI
constant     43.1466      1.0239    42.1401     .0000    41.1321    45.1611
COPE_M       -1.2804       .4264    -3.0025     .0029    -2.1194     -.4414
COPE_W       -2.1084       .4206    -5.0131     .0000    -2.9359    -1.2809

------------------------------

Correlation of residuals in total effect models:
     .5202
```

MEDYAD output

(indirect effects)

Indirect effects of the husband's inability to cope on his own marital satisfaction, one through his own depression, the other through his spouse's.



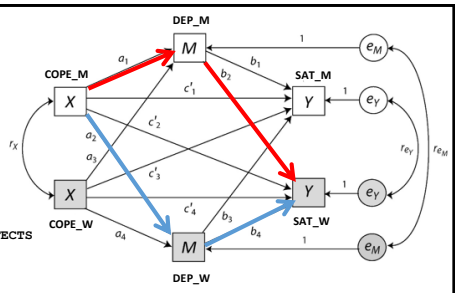

```
********************** TOTAL, DIRECT, AND INDIRECT EFFECTS

TOTAL, DIRECT, AND INDIRECT EFFECTS OF
 COPE_M

Total effect(s) on
          effect         se          t          p       LLCI       ULCI
SAT_M    -2.1685      .3979    -5.4503     .0000    -2.9513    -1.3857
SAT_W    -1.2804      .4264    -3.0025     .0029    -2.1194     -.4414

Direct effect(s) on
          effect         se          t          p       LLCI       ULCI
SAT_M     -.8419      .4142    -2.0324     .0430    -1.6569     -.0269
SAT_W     -.2214      .4448     -.4977     .6191    -1.0965      .6538

Indirect Effect(s):
          effect     BootSE   BootLLCI   BootULCI
Ind1     -1.3146      .2484    -1.8400     -.8544
Ind2      -.0120      .0649     -.1348      .1304
Ind3     -1.0366      .2391    -1.5087     -.5715
Ind4      -.0224      .1171     -.2456      .2227

Indirect Effect Key:
 Ind1     :        COPE_M   -->      DEP_M    -->      SAT_M
 Ind2     :        COPE_M   -->      DEP_W    -->      SAT_M
 Ind3     :        COPE_M   -->      DEP_M    -->      SAT_W
 Ind4     :        COPE_M   -->      DEP_W    -->      SAT_W
```

95% bootstrap confidence intervals (percentile method)

MEDYAD output

(indirect effects)

Indirect effects of the husband's inability to cope on his spouse's marital satisfaction, one through his own depression, the other through hers.



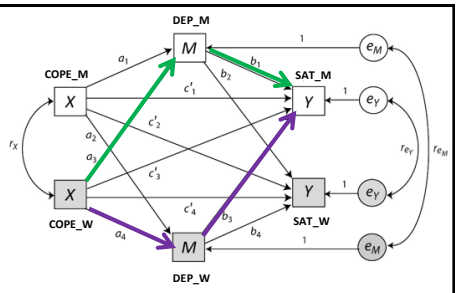

```
********************** TOTAL, DIRECT, AND INDIRECT EFFECTS

TOTAL, DIRECT, AND INDIRECT EFFECTS OF
 COPE_M

Total effect(s) on
          effect         se          t          p       LLCI       ULCI
SAT_M    -2.1685      .3979    -5.4503      .0000    -2.9513    -1.3857
SAT_W    -1.2804      .4264    -3.0025      .0029    -2.1194     -.4414

Direct effect(s) on
          effect         se          t          p       LLCI       ULCI
SAT_M     -.8419      .4142    -2.0324      .0430    -1.6569     -.0269
SAT_W     -.2214      .4448     -.4977      .6191    -1.0965      .6538

Indirect Effect(s):
         effect     BootSE   BootLLCI   BootULCI
Ind1    -1.3146      .2484    -1.8400     -.8544
Ind2     -.0120      .0649     -.1348      .1304
Ind3    -1.0366      .2391    -1.5087     -.5715
Ind4     -.0224      .1171     -.2456      .2227

Indirect Effect Key:
 Ind1     :        COPE_M   -->      DEP_M    -->      SAT_M
 Ind2     :        COPE_M   -->      DEP_W    -->      SAT_M
 Ind3     :        COPE_M   -->      DEP_M    -->      SAT_W
 Ind4     :        COPE_M   -->      DEP_W    -->      SAT_W
```

95% bootstrap confidence intervals (percentile method)

MEDYAD output

(indirect effects)

Indirect effects of the wife's inability to cope on her husband's marital satisfaction, one through her own depression, the other through his.



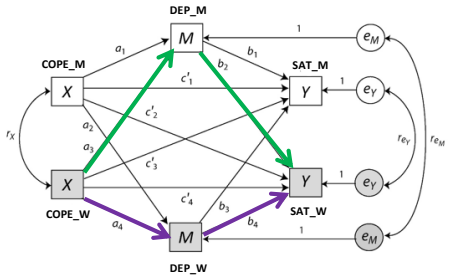

```
TOTAL, DIRECT AND INDIRECT EFFECTS OF
 COPE_W

          effect         se          t          p       LLCI       ULCI
SAT_M    -1.1545      .3924    -2.9421      .0035    -1.9265     -.3824
SAT_W    -2.1084      .4206    -5.0131      .0000    -2.9359    -1.2809

Direct effect(s) on
          effect         se          t          p       LLCI       ULCI
SAT_M     -.4370      .4067    -1.0746      .2834    -1.2372      .3632
SAT_W     -.9128      .4367    -2.0903      .0374    -1.7720     -.0536

Indirect Effect(s):
         effect     BootSE   BootLLCI   BootULCI
Ind5     -.1325      .1597     -.4426      .1713
Ind6     -.5850      .1972     -.9776     -.2050
Ind7     -.1045      .1313     -.3873      .1275
Ind8    -1.0911      .2345    -1.5687     -.6415

Indirect Effect Key:
 Ind5     :        COPE_W   -->      DEP_M    -->      SAT_M
 Ind6     :        COPE_W   -->      DEP_W    -->      SAT_M
 Ind7     :        COPE_W   -->      DEP_M    -->      SAT_W
 Ind8     :        COPE_W   -->      DEP_W    -->      SAT_W
```

95% bootstrap confidence intervals (percentile method)

MEDYAD output

(indirect effects)

Indirect effects of the wife's inability to cope on her own marital satisfaction, one through her own depression, the other through his.




```
TOTAL, DIRECT AND INDIRECT EFFECTS OF
 COPE_W

          effect         se          t          p       LLCI       ULCI
SAT_M    -1.1545      .3924    -2.9421     .0035    -1.9265    -.3824
SAT_W    -2.1084      .4206    -5.0131     .0000    -2.9359   -1.2809

Direct effect(s) on
          effect         se          t          p       LLCI       ULCI
SAT_M     -.4370      .4067    -1.0746     .2834    -1.2372     .3632
SAT_W     -.9128      .4367    -2.0903     .0374    -1.7720    -.0536

Indirect Effect(s):
          effect     BootSE   BootLLCI   BootULCI
Ind5      -.1325      .1597     -.4426      .1713
Ind6      -.5850      .1972     -.9776     -.2050
Ind7      -.1045      .1313     -.3873      .1275
Ind8     -1.0911      .2345    -1.5687     -.6415

Indirect Effect Key:
 Ind5     :        COPE_W    -->      DEP_M     -->      SAT_M
 Ind6     :        COPE_W    -->      DEP_W     -->      SAT_M
 Ind7     :        COPE_W    -->      DEP_M     -->      SAT_W
 Ind8     :        COPE_W    -->      DEP_W     -->      SAT_W
```

95% bootstrap confidence intervals (percentile method)

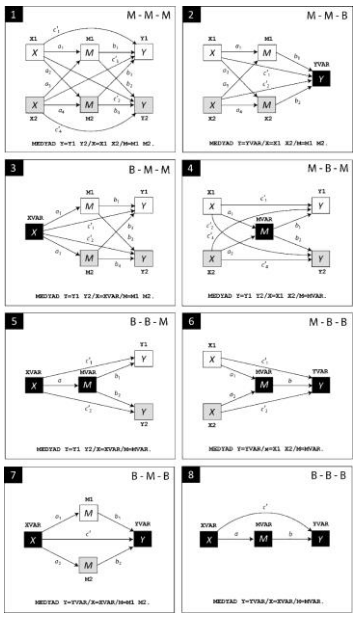
Some other single-mediator models

In the APIMeM, *X*, *M*, and *Y* are all mixed variables. Variation exists both within and between-dyads.

A between-dyad variable exhibits no variation within-dyad. All variation is between dyads.

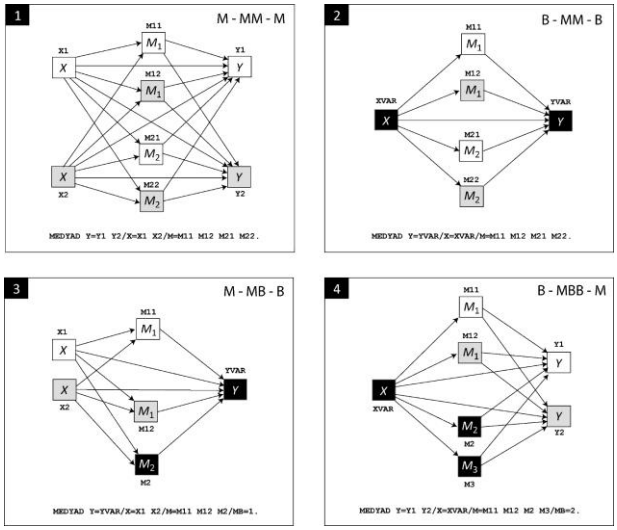
Combining *X*, *M*, and *Y*, with the mixed/between distinction generates eight possible models, diagrammed to the right, with a between-dyad variable represented with a black box and mixed variables represented with pairs of white and gray boxes.

MEDYAD can estimate <u>all</u> of these. Only a single line of code is required.



More than one mediator

MEDYAD allows up to 12 mediators (up to 6 mixed variables, 12 between-dyad variables, or combinations of mixed and between). Some examples are below. **MEDYAD can estimate these and many, many, many others. Still, only a single line of code is required.**



Some benefits of MEDYAD

- Very easy to learn and use
- SAS and SPSS are readily accessible to most (working at universities)
- Faster than SEM programs (with respect to estimation time and set up)
- The same conclusions as SEM programs will provide
- Tiny changes in syntax to estimate different models

..but relative to SEM:

- Observed variable models only
- Requires continuous *Y* and *M*
- No sophisticated procedures for dealing with missing data
- OLS is the only option available for estimation.
- Not possible to impose constraints (e.g., fixing *X*→*M* to be the same for each member of the dyad).
- No ability to configure mediators in serial form.
- No measures of "fit" like in SEM. Not necessarily a limitation really, as focus is on estimation of effects, not overall model quality. All models MEDYAD estimates are "saturated" so fit is perfect by SEM standards.

How can I get it?

As of May 2019, MEDYAD is currently going through beta testing. But you can get a beta version now by filling out a form to download the files and documentation.

www.afhayes.com or www.jjcoutts.com

and hunt for a few seconds for MACROS or MEDYAD