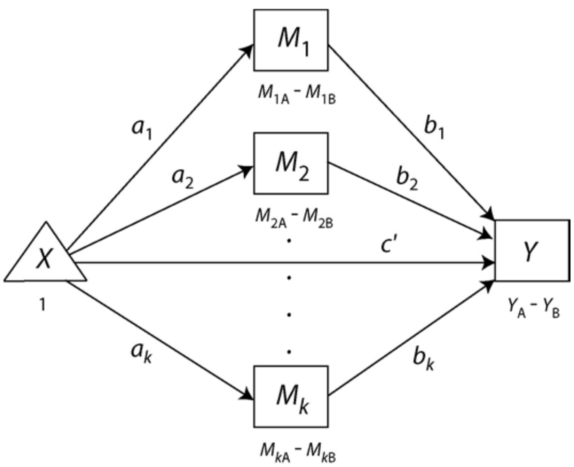
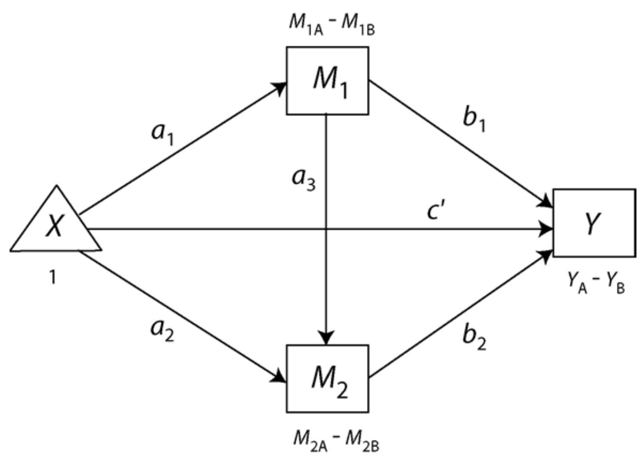
MEMORE

```
MEMORE Y = depA depB /M = med1A med1B [med2A med2B...]
                                      [/MC = {mc}{0**}]
                                      [/BC = {bc}(0**)]
                                      [/NORMAL = {n}(0**)]
                                      [/CONF = {c}{95**}]
                                      [/SAMPLES = {sm}(5000**)]
                                      [/CONTRAST = {cn}(0**)]
                                      [/SAVE = {sv}{0**}]
                                      [/SEED = {sd}{random**}]
                                      [/SERIAL = {s}{0**}]
                                      [/DECIMALS = {dc}{F10.4**}].
```

Subcommands in brackets are optional
** Default if subcommand is omitted





Note: The diagrams above excludes mean centered means of mediator. These are included in the model that MEMORE estimates. See Montoya and Hayes (in press) for details.

Overview

`MEMORE` (pronounced like "memory") is a macro that estimates the total, direct, and indirect effects of X on Y through one or more mediators M in the two-condition or two-occasion within-subjects/repeated measures design. In a path-analytic form using OLS regression as illustrated in Montoya and Hayes (in press), it implements the method described by Judd, Kenny, and McClelland (2001) for single mediators while extending it as described in Montoya and Hayes (in press) to multiple mediators operating in parallel or serial. Along with an estimate of the indirect effect(s), `MEMORE` generates confidence intervals for inference about the indirect effect(s) using bootstrapping, Monte Carlo, or normal theory approaches. `MEMORE` also provides an option that conducts pairwise contrasts between specific indirect effects in models with multiple mediators.

Preparation for Use

The MEMORE.sps file should be opened as a syntax file in SPSS. Once it has been opened, execute the entire file exactly as is. Do not modify the code at all. Once the program is executed, the MEMORE.sps file window can be closed. Access to the `MEMORE` command is available after activation until quitting SPSS. The MEMORE.sps file must be loaded and reexecuted each time SPSS is opened. To install `MEMORE` permanently in SPSS, install the custom dialog version (see below).

Model Specification

Unlike in between-subjects mediation analysis, the data file for a within-subjects mediation analysis generally does not contain a column coding the X variable. As a result, there is no specification of the X variable in the `MEMORE` code. Rather, the X variable is represented in the data by two repeated measurements of the mediator(s) and dependent variable in the data file, and it is the repeated measurements of M and Y that appear in the `MEMORE` code. For instance, X might be a manipulation of content in a stimulus, with each participant in the study receiving stimulus version A and stimulus version B. Each participant's measurement of the mediator and outcome is collected following exposure to each of the two stimuli. If in the data the mediator measurements are variables `medA` and `medB` following exposure to stimulus A and B, respectively, and the dependent variables measurements are variables `depA` and `depB` following exposure to stimulus A and B, then

```
MEMORE Y=depA depB/M=medA medB.
```

estimates the direct and total effects of independent variable X (the content manipulation) on dependent variable Y as well as the indirect effect of X on Y through mediator M and produces a bootstrap confidence interval for the indirect effect based on 5,000 bootstrap samples.

Various options are available in `MEMORE` to control the confidence level, number of samples used for inference, pairwise comparisons between specific indirect effects, and so forth. For example,

```
MEMORE Y=depA depB/M=medA medB/conf=99/mc=1/samples=10000/save=1.
```

estimates the effects of X, produces 99 percent confidence intervals for all model estimates, generates a Monte Carlo confidence interval for the indirect effect based on 10,000 samples, and saves the Monte Carlo estimates to a data file.

`MEMORE` constructs the difference between the two mediator measurements and the difference between the two dependent variable measurements, and these are modeled in accordance with the procedure described in Montoya and Hayes (in press) and Judd et al. (2001). `MEMORE` constructs the difference score as $M_A - M_B$ and $Y_A - Y_B$, where M_A and M_B are the mediator measurements following `M=` and Y_A and Y_B are the dependent variable measurements following `Y=`. The order these are listed in following `M=` and `Y=` matters for the sake of the construction of the difference, and the order must be consistent between the `M=` and `Y=` lists. For instance, if the dependent variable in condition A is listed first following `Y=`, then the mediator in condition A should also be listed first following `M=`. The top of the output will denote how the difference scores were constructed based on the `MEMORE` code submitted. Check this section of the output for consistency with your intentions before interpreting the results.

Multiple Mediators

`MEMORE` can estimate specific indirect effects of X on Y in models with up to 10 mediators operating in parallel, or two in serial, as well as the total indirect effect of X on Y aggregated across all mediators. As mediators must come in pairs of measurements, in a model with k parallel mediators, there should be $2k$ variables provided in the `M=` list. The pairs should come in sequence of the mediators, with the occasion of measurement within each pair also preserved across pairs in the `M=` list. For instance, suppose three mediators M_1, M_2, and M_3 were each measured following stimulus A and stimulus B. In that case the `MEMORE` command for a parallel multiple mediator model would be

```
MEMORE Y=depA depB/M=med1A med1B med2A med2B med3A med3B.
```

where **depA** and **depB** are the measurement of the dependent variable following stimulus A and B, med1A and med1B are the measurements of mediator 1 following stimulus A and B, med2A and med2B are the measurements of mediator 2 following stimulus A and B, and med3A and med3B are the measurements of mediator 3 following stimulus A and B. Check the top of the output carefully to make sure MEMORE is constructing the difference scores as expected given the order in which the variables in M= are listed.

For a discussion of the parallel multiple mediator model, see Preacher and Hayes (2008) or Hayes (2013, Chapter 5).

For the serial mediator model, the order of the two pairs (MEMORE allows only two pairs for a serial model) in the M= list dictates the presumed direction of causal flow. The serial mediation model is specified by setting the s argument in the serial option to 1 (i.e., serial=1) in the MEMORE command. Thus, the MEMORE command below estimates a serial multiple mediator model with mediator 1 (med1A and med1B) causally prior to mediator 2 (med2A and med2B):

```
MEMORE Y=depA depB/M=med1A med1B med2A med2B/serial=1.
```

In the parallel and serial multiple mediator models, all direct and indirect effects are freely estimated. It is not possible to constrain a direct effect to zero using MEMORE.

Inference for Indirect Effects

By default, MEMORE generates percentile bootstrap confidence interval for inference about the indirect effect based on 5,000 bootstrap samples. Bias corrected bootstrap and Monte Carlo confidence intervals are also available. To generate a Monte Carlo confidence interval instead of a bootstrap confidence interval, use the MC option, setting its argument to 1 (i.e., MC=1). To generate a bias corrected bootstrap confidence interval, use the BC option, setting its argument to 1 (i.e., BC=1). The lower and upper bounds of bootstrap confidence intervals are listed in the output under BootLLCI and BootULCI, respectively, whereas Monte Carlo confidence interval estimates are denoted MCLCCI and MCULCI. In a single run of MEMORE, a confidence interval is generated using only one method. The Monte Carlo confidence interval takes precedence when both the bias corrected confidence interval and Monte Carlo method are specified in a MEMORE command.

The standard error of the indirect effect is not required for confidence interval construction for the indirect effect when using bootstrapping or Monte Carlo methods. However, MEMORE does produce an estimate of the standard error of the indirect effect. This standard error is the standard deviation of the distribution of the bootstrap or Monte Carlo estimates. It appears in the output as BootSE (when using bootstrapping) or MCSE (when using the Monte Carlo method).

The NORMAL option generates a test of significance for the indirect effect using the Sobel test (Sobel, 1982). The Sobel test assumes that the sampling distribution of the indirect effect is normal, an assumption which has been shown to be inaccurate. To produce the Sobel test, set the n argument in the NORMAL option to 1 (i.e., NORMAL = 1). By default, MEMORE does not produce this test in the output.

Confidence Interval Width

The c argument in the CONF option specifies the desired confidence for confidence interval-based inference. The default is 95%. Confidence can be specified anywhere between 50 and 99.99% (e.g., `CONF=99` generates 99% confidence intervals). Note that the closer the confidence level requested gets to one, the more bootstrap or Monte Carlo samples are required in order to generate trustworthy confidence intervals for inference about indirect effects. If the number of bootstrap or Monte Carlo samples requested is too small to construct a confidence interval of the desired confidence, the program will not run and an error will appear in the "Analysis Notes and Warnings" section of the output.

Number of Samples for Bootstrap and Monte Carlo Inference

The `SAMPLES` option sets the number of samples used in the generation of bootstrap or Monte Carlo confidence intervals for inference about indirect effects. The `sm` argument defaults to 5000 and can be set to any integer between 1000 and infinity. Any number less than 1000, except zero, is ignored, and the default is implemented. If zero is specified, `MEMORE` generates a Monte Carlo confidence interval for indirect effects based on 5000 samples.

Covariates

There are no options available in `MEMORE` for the inclusion of covariates in the model. When a covariate is fixed across measurements of mediators and outcome (such as gender or some other stable individual difference) and it is assumed that the covariate's effect on each mediator repeatedly measured is the same, as is the covariate's effect on each outcome repeatedly measured, then the effect of the covariate on mediator and covariate differences becomes ignorable and thus the covariate can be excluded from the model.

Pairwise Contrasts Between Specific Indirect Effects

In models with more than one mediator, setting the `cn` argument in the `CONTRAST` option to one (i.e., `CONTRAST=1`) generates pairwise contrasts between all specific indirect effects, including bootstrap or Monte Carlo confidence intervals for inference. When there are only two repeated mediator variables in the model, the contrast between specific indirect effects is listed in the output as `(C1)`. With k repeated mediators in parallel, the $0.5k(k-1)$ possible pairwise contrasts are listed as `(C1)`, `(C2)`, `(C3)`, and so forth, and a key for interpreting which code corresponds to which contrast is provided.

Saving Bootstrap and Monte Carlo estimates

The `SAVE` subcommand generates a data file visible through the SPSS Data Viewer containing regression coefficients produced through bootstrap or Monte Carlo sampling. When bootstrapping, all model regression coefficients are saved. When using the Monte Carlo method, only the model coefficients that define the indirect effect(s) are saved. This file can be used for visualizing sampling distributions or the construction of custom hypothesis tests involving functions of regression coefficients. By default, this file is not created. To activate this option, specify `SAVE=1` in the `MEMORE` command. The file is not permanently saved to a storage device, so this file should be saved for future use if desired. Subsequent runs of `MEMORE` without first saving the file produced by a prior run will erase the old file in favor of the new file.

Seeding the Random Number Generator

Bootstrap and Monte Carlo confidence intervals require random resampling of the data or from theoretical distributions and thus will differ from run to run of `MEMORE` even when the data and model are the same. The `SEED` option can be used to seed the random number generator, thereby allowing for the replication of the output from run to run when analyzing the same data. By default `MEMORE` sets the seed randomly. The `sd` argument in the `SEED` command can be set to any positive integer that is less than or equal to 2,000,000. When this option is used, the random number seed specified is printed in the output for later reference.

Decimal Precision in Output

Output precision, in the form of number of decimal places of resolution, can be set with the `dc` argument in the `DECIMALS` command. The default for `dc` is F10.4, meaning 10 characters and four points to the right of the decimals place. Changing this to, for example, F8.2 will allocate eight characters with two to the right of the decimal point. See the *SPSS Syntax Reference Manual* for additional format options.

MEMORE Custom Dialog

A Custom Dialog version of `MEMORE` can be permanently housed in the SPSS menus. To do so, install the MEMORE.spd (UI Dialog Builder) file by double clicking, right clicking, or opening and install it from within SPSS under the Utilities menu. Administrative access to the computer is required. This should install a new `MEMORE` option under the SPSS "Analyze→Regression" menu. Without administrative access, a local information technology specialist will be required for assistance in setting up administrative access to the computer and installing the dialog file.

Notes

- A case will be deleted from the analysis if missing on any of the variables in the model.
- All variable names must be 8 characters or fewer in length.
- Exactly two variables containing measurements of *Y* must be listed following `Y=`.
- Mediator measurements must be listed in sets of 2. Listing an odd number of variables in the `M=` list will produce an error.
- Do not use STRING formatted variables in any of your models. Doing so will produce errors. All variables should be in NUMERIC format.

References

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis.* New York: The Guilford Press.

Judd, C. M., Kenny, D. A., & McClelland, G. H. (2001). Estimating and testing mediation and moderation in within-subjects designs. *Psychological Methods, 6*, 115-134.

Montoya, A. K., & Hayes, A. F. (in press). Two condition within-participant statistical mediation analysis: A path-analytic framework. *Psychological Methods.*

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891.