Computer Intensive Methods (Chapter 12)

Purpose is to use the data itself to form a distribution of a statistic (Manly, 1997). Does not make as many assumptions and can handle nonnormal distributions.

The value of a statistic in the observed sample is compared to the distribution of the statistic formed by resampling from the observed data a large number of times.

Bootstrap method for mediated effects described by Bollen & Stine (1991), Lockwood & MacKinnon (1998), and Shrout & Bolger (2002)

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Options to make Confidence Limits

- Normal theory yields symmetric confidence limits.
- Distribution of the Product for asymmetric confidence limits.
- Resampling methods for asymmetric confidence limits—many different types of resampling methods including the bootstrap and jackknife.

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Bootstrap Confidence Limits

1. Estimate mediated effect in the original sample
2. Generate new data based on sampling with replacement from the original data
3. Calculate effect in the generated data
4. Repeat steps 2 and 3 a large number of times
5. Create empirical distribution of the effect from generated and original data
6. Compute UCL and LCL in the empirical distribution.

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Bootstrap in groups

- Observed Data set with N = 6

Obs	X	M	Y
1	1	2	-4
2	1	5	-6
3	2	8	-14
4	2	9	-16
5	-1	-7	12
6	0	0	-1

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Bootstrap Sample 1

Six rolls of the dice gave, 1, 5, 2, 3, 1, 2

Obs	x	m	y
1	1	2	-4
5	-1	-7	12
2	1	5	-6
3	2	8	-14
1	1	2	-4
2	1	5	-6

So this is a bootstrap sample. Note that sampling is with replacement so observations 1 and 2 are repeated twice and observations 4 and 6 were not sampled. The mediated effect would be calculated for this sample and the process is repeated a large number of times.

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Group Members

- **Randomizer** rolls the die.
- **Recorder** writes the data.
- **Analyzer** analyzes the data.
- **Reporter** describes results.

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Bootstrap sampling

- **Randomizer** rolls the die 6 times and records the number for each roll. These are the Obs numbers of participants selected for the bootstrap sample.
- **Recorder** writes the data for X, M, and Y for each Obs number. Note that Obs numbers could be in the sample several times.
- **Analyzer** types the bootstrapped data in SAS and estimates the mediated effect. You will be asked for your the mediated effect in your sample.
- **Reporter** reports the value of the mediated effect for the bootstrap sample.

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Bootstrap Confidence Intervals

- Write down the mediated effect from each bootstrap sample.
- Form a distribution of the bootstrap sample estimates of the mediated effect. Order mediated effects from large to small for bootstrap and original sample: -15.7234, **-6.4202**, -5.1223, -.3.2241, -1.9433, 0.34… (a sample could be undefined because $\hat{b}$ could not be estimated)
- Find the value of the mediated effect in the bootstrap samples corresponding to the 2.5% and 97.5%. These are the bootstrap 95% confidence intervals.
- Confidence limits require a large number of bootstrap samples, such as 1000 so that the confidence limits are the 2.5th and 97.5th values in the bootstrap distribution.
- Best to use a computer program to do the bootstrap sampling and analysis. It would take us a while to take 999 bootstrap samples.

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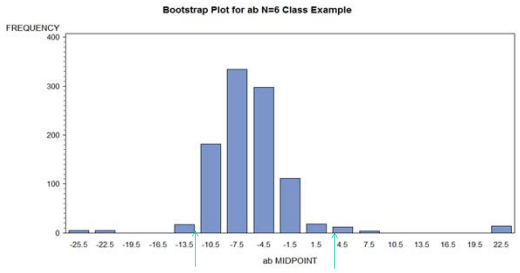

LCL=-12.67 2.5%

UCL=3.56 97.5%

95% Confidence Interval

Bootstrap Confidence Intervals

95% Confidence interval from Percentile bootstrap
LCL = -12.667 and UCL =3.556

95% Confidence interval from Bias-Corrected Bootstrap
LCL = -13.2 UCL = 2.706

Percentile Bootstrap mean = -6.3578
Percentile Bootstrap Median = -5.8728
Bias-corrected bootstrap makes a new percentile for the LCL and UCL based on the discrepancy between the observed mediated effect and average bootstrap mediated effect.

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Mplus Mediation Analysis

- Mplus will estimate mediated effects and their standard errors.
- MODEL INDIRECT: Y IND X; estimates indirect effects from X to Y and standard errors.
- For the single mediator model there is one indirect effect from X to M to Y and one standard error.
- For multiple mediator models there may be many mediated effects from X to Y. Each of the individual mediated effects are called specific mediated effects and Mplus will estimate each specific mediated effect and compute a standard error for each specific mediated effect.
- The data here have one mediator so there is one mediated effect.

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Mplus Bootstrap Analysis

- Mplus will estimate mediated effects and conduct bootstrap sampling
- Analysis: Bootstrap=1000: specifies 1000 bootstrap samples
- OUTPUT: Cinterval; to obtain normal distribution confidence intervals.
- OUTPUT: Cinterval(bootstrap) to obtain bootstrap confidence intervals.
- OUTPUT: Cinterval(bcbootstrap) to obtain bias-corrected bootstrap confidence intervals. Bias corrected bootstrap confidence intervals adjust the interval to reflect that the average bootstrap mediated effect is not the same value of the mediated effect in the original sample (see Chapter 12).
- See Mplus Handout

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How the data were generated.

- The data were generated with population values of *a* = 4 (true standard error of .25), *b* = -2 (.333), and *c'* = 1(.333) so the population mediated effect, *ab*, was -8 and the true standard error of the estimated mediated effect was equal to 2.5331 so the true z' equals 3.1582.
- In summary, six observations were generated from a population with a real mediated effect of -8. So the correct decision is to say that there is a mediated effect in these data. Normal theory analysis of these data and the bias corrected bootstrap led to the correct conclusion but the percentile bootstrap did not.

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Bootstrap 'mediation'

mediation

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Resampling Methods Summary

- Now widely used method for a variety of reasons, applicability in complicated situations where analytical solutions are not known or untenable.
- Useful for mediation analysis because it can be used for any mediation model with complex mediated effects when the distribution of the effects is not known.
- Some limitations: generalizing beyond the sample at hand may not be appropriate, software can be difficult to implement, and Gleser's law, "Two individuals using the same statistical method should arrive at the same conclusion."
- Other Resampling Methods: Permutation, bootstrap t, bootstrap Q, Jackknife, Monte Carlo…

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