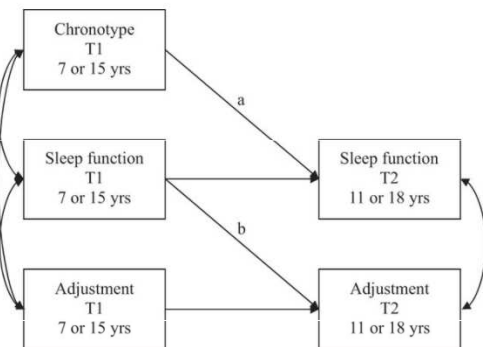
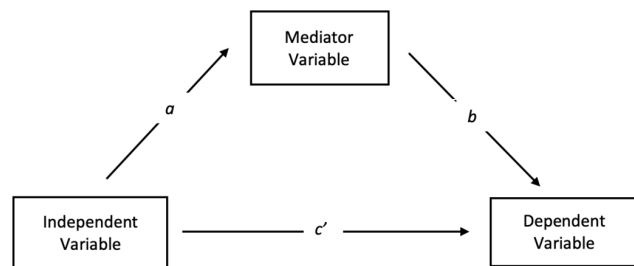


# Mediation Analysis

E0420  
Week 11



# What is Mediation?

## 1. Conceptual issue

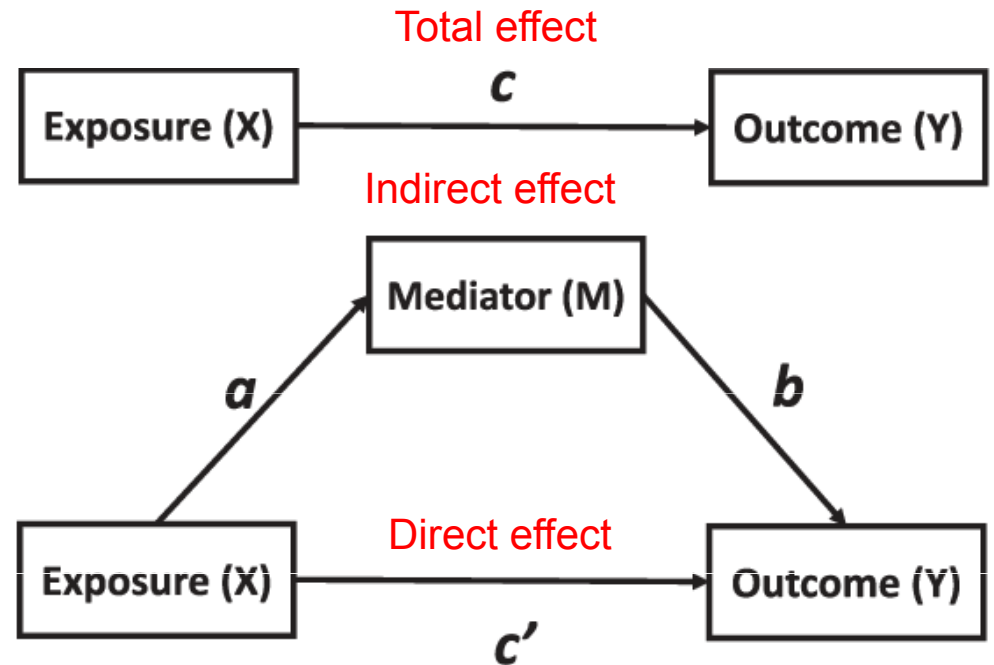
- Hypothesis about the nature of the associations between variables
- The relationship between exposure (X) and outcome (Y) can be explained by their relationship to a third variable (M)
- Information about *mechanism* or *process* by which X and Y are linked

# A Side Note - Mediation vs. Moderation

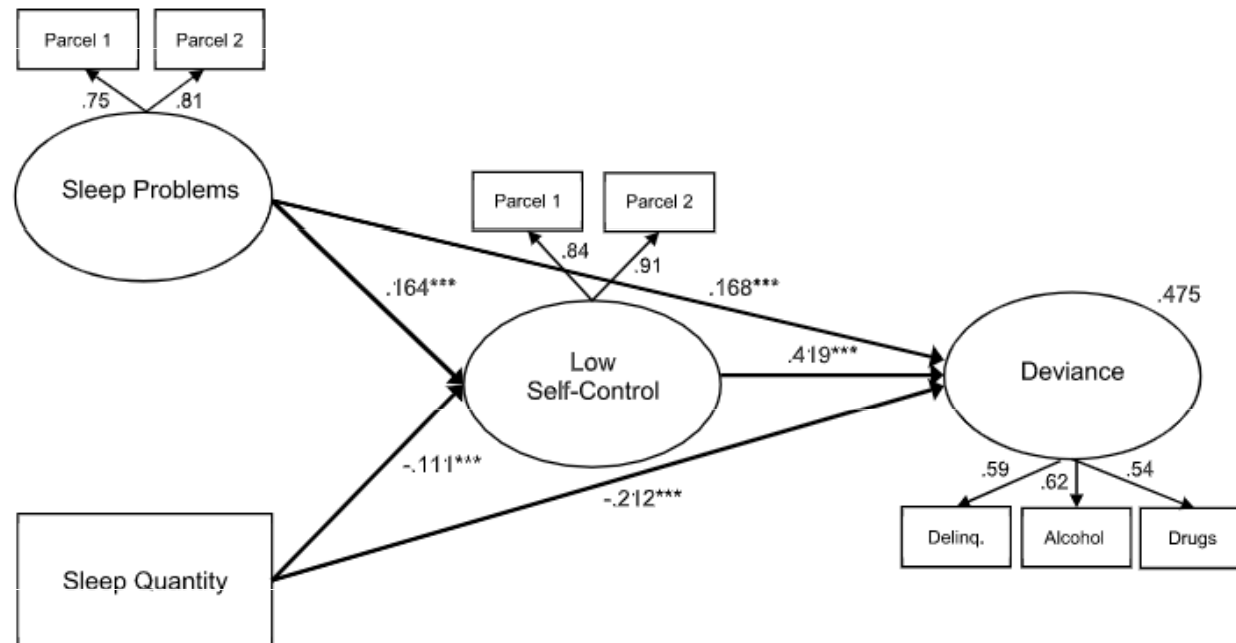
- **Mediator:** middle-person, letter carrier, delivery agent
  - $X \rightarrow M \rightarrow Y$
  - Mediation answers questions about WHY or HOW a relation exists
- **Moderator:** “changer”
  - variable that alters the strength of another relationship (i.e., an interaction!)
  - Moderation occurs when the effect of X on Y *depends* on Z
  - Moderation answers questions about for WHOM or WHEN a relation exists
- Mediation can be moderated

# What is Mediation?

- There is relationship between X and Y (c path)
- X (a path) and Y (b path) are also related to a third variable – mediator variable (M)
- The relationship between X and Y is changed (attenuated) after including M into the model (c' path)
- Perfect mediation occurs when c' path drops to 0
- a, b, c, and c' represent B or  $\beta$  regression coefficients



# Real-life Example



Vazsonyi, A. T., Ksinan Jiskrova, G., & Ksinan, A. J. (2018). Sleep, low self-control, and deviance: Direct and indirect links across immigrant groups and socioeconomic strata. *Journal of Adolescence*, 68, 40-49.

# What is Mediation?

## **2. Regression-based statistical procedure**

- Series of regression analyses/complex regression used to test the magnitude and significance of paths in our conceptual/hypothesized model
- PROCESS macro for SPSS (OLS regression)
- Structural equation modeling (SEM) approach (ML estimation)

# Mediation Analysis

## Baron & Kenny (1986)

Traditional approach to testing mediation (“causal steps”)

1. Test the association between X and Y (path c)
2. Test the association between X and M (path a)
3. Test the association between X and Y, controlling for M (paths b and c'). B path must be sig. and c' must be less than c

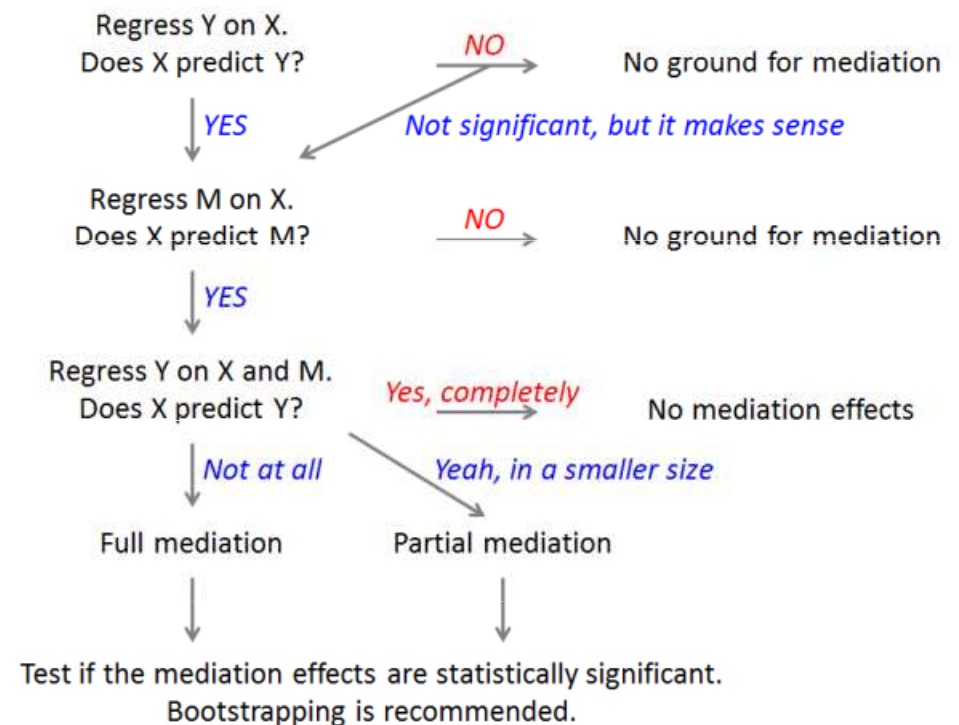
**In the classic approach, mediation criteria are met when c' is not significant**

The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations.

RM Baron, DA Kenny - Journal of personality and social ..., 1986 - psycnet.apa.org

In this article, we attempt to distinguish between the properties of moderator and mediator variables at a number of levels. First, we seek to make theorists and researchers aware of the importance of not using the terms moderator and mediator interchangeably by carefully elaborating, both conceptually and strategically, the many ways in which moderators and mediators differ. We then go beyond this largely pedagogical function and delineate the conceptual and strategic implications of making use of such distinctions with regard to a ...

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# The problem with Traditional Approach

- In the classic approach, mediation criteria are met when  $c'$  is not significant
- In practice, this rarely happens
  - Does it mean that there is no mediation?
  - How much of an effect there has to be to conclude that mediation is occurring?
- More modern approaches test whether there is **a significant indirect effect**
  - The association between the X and Y that goes through M
  - The product of paths a and b in our model ( $a*b$ )



# Partial vs. Full Mediation

- In full mediation, adding M to the model predicting Y makes the association between the X and Y non-significant
  - Thus, M fully accounts for the association between X and Y
- In partial mediation, there is a significant indirect effect, but the remaining direct effect is still significant
  - Thus, M is only one reason that the X is related to the Y (Which is OK!)
- The determination between them is solely whether  $c'$  is significant or not

# Sobel (1982)

- The most common test of the significance of the indirect effect is a z test developed by Sobel:

$$Z_{Sobel} = \frac{ab}{\sqrt{b^2 s_a^2 + a^2 s_b^2}}$$

- Where a and b are the estimates of the paths involved in the indirect effect, and  $s_a^2$  and  $s_b^2$  are the variance of the a and b paths

# The problem with Sobel

- The Sobel (1982) test assumes that the test statistic it produces follows a normal distribution (the z distribution)
  - Unfortunately, it does not
  - The indirect effect does not; nor does any product of two regression coefficients
- What this means is that the significance test (or any CI we compute) will be inaccurate

# Solutions

Mediation in experimental and nonexperimental studies: new procedures and recommendations.

[PE Shrout, N Bolger](#) - Psychological methods, 2002 - psycnet.apa.org

Mediation is said to occur when a causal effect of some variable X on an outcome Y is explained by some intervening variable M. The authors recommend that with small to moderate samples, bootstrap methods (B. Efron & R. Tibshirani, 1993) be used to assess mediation. Bootstrap tests are powerful because they detect that the sampling distribution of the mediated effect is skewed away from 0. They argue that RM Baron and DA Kenny's (1986) recommendation of first testing the X→Y association for statistical significance ...

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- MacKinnon and colleagues (2002)
  - The statistic follows a gamma distribution, the shape of which depends on the values of a and b
  - MacKinnon's test statistics performs well but it is unnecessarily complicated
- Shrout and Bolger (2003)
  - Applied **bootstrapping technique** to the study of mediation
  - Bootstrapping turned out to be the best approach developed so far

# Bootstrapping

- Bootstrapping is a resampling method
- Take a sample of size  $N$
- Randomly draw from this sample (WITH REPLACEMENT) another sample of size  $n$
- For this new (bootstrap) sample, compute the statistic of interest (e.g., the indirect effect  $a*b$ )
- Repeat about 1000 times
- Use the 1000 estimates of the indirect effect to compute a CI

# Bootstrapping

- The CI is computed by ordering all 1000 estimates from lowest to highest
- You can then figure which one marks the bottom 2.5% (that would be the 25<sup>th</sup> value in your ordering)
  - This is the lower limit of the CI
- The upper limit would be the 975<sup>th</sup> value in your ordering
- Because the CIs are computed this way, it makes no assumptions about the shape of the distribution (it's nonparametric)
- Note this only works if your sample is representative

# Testing Mediation Effect (with bootstrapped CIs)

- PROCESS macro for SPSS
  - Preacher and Hayes have developed macros for SPSS, SAS, and R that will bootstrap the indirect effect
  - Free for download: <https://www.processmacro.org/index.html>
- Structural equation modeling (SEM) software
  - R (Lavaan package - <https://lavaan.ugent.be/>), Mplus, STATA, AMOS
- SEM approach uses different estimation method than PROCESS macro and is more versatile

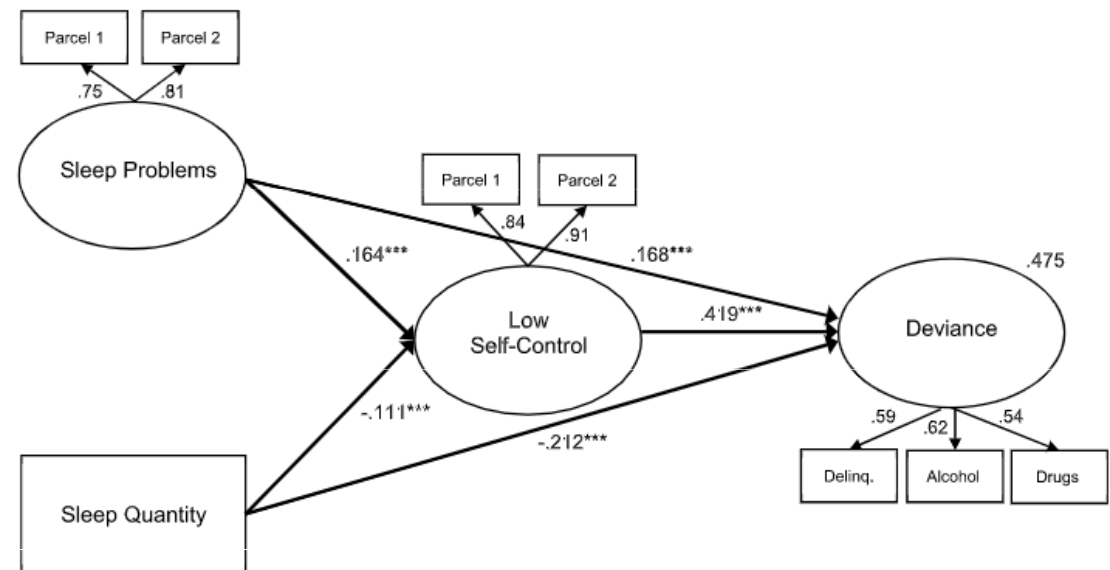
# Conceptual Considerations

- Mediation is key to developing and testing theoretical models
- Correlation does not imply causation **STILL APPLIES!**
- Establishing causality is a methodological issue, not a statistical one
- Mediation is best tested with longitudinal or experimental data
  - Experimental manipulation of the mediator
  - Temporal sequence



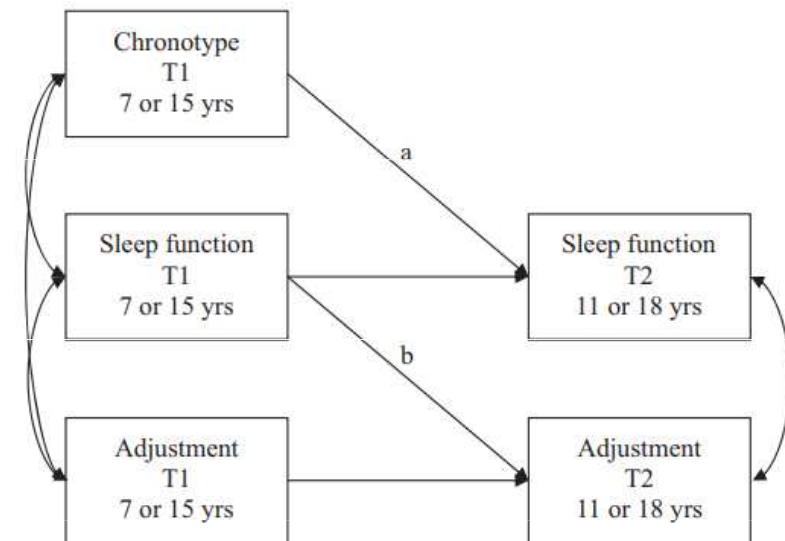
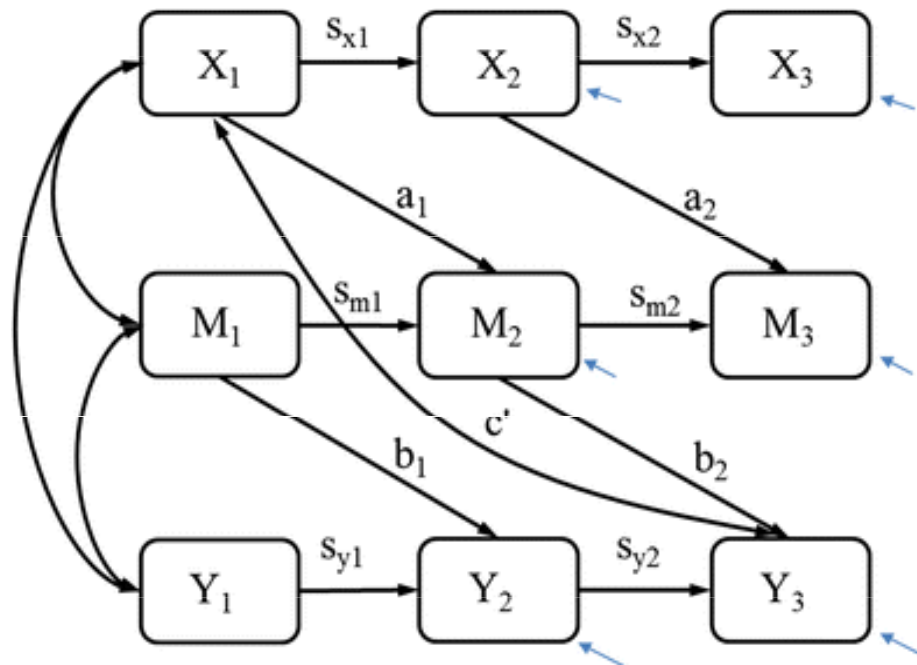
# Mediation with Cross-sectional Data

- Good theory behind the hypothesized direction of the paths needed
  - Support for each of the hypothesized paths
- Test of competing hypotheses/models
  - Bidirectional associations
  - Reverse direction of the effect



# Longitudinal and Half-longitudinal Mediation Model

- Explicitly models change in both Y and M
- Permits experimental manipulation of both X and M



Wu, W., Carroll, I. A., & Chen, P. Y. (2018). A single-level random-effects cross-lagged panel model for longitudinal mediation analysis. *Behavior research methods*, 50(5), 2111-2124.

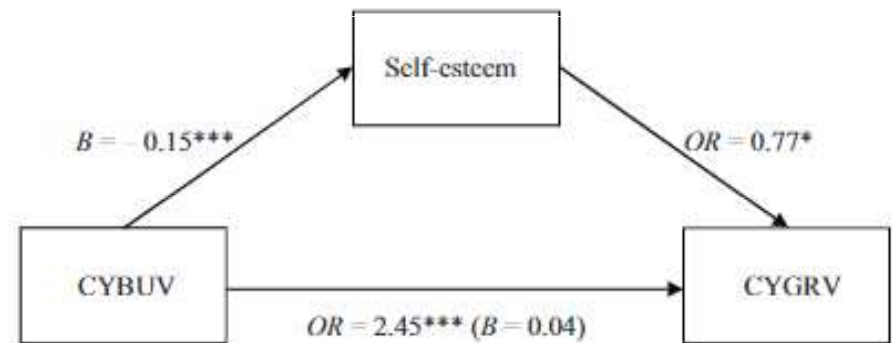
Ksian Jiskrova, G., Vazsonyi, A. T., Klánová, J., & Dušek, L. (2019). Sleep quantity and problems as mediators of the eveningness-adjustment link during childhood and adolescence. *Journal of youth and adolescence*, 48(3), 620-634.

# The Term Mediation

- The term mediation is sort of a loaded word, because there is so much controversy about the best method
- For many, you cannot use “mediation” unless you follow the traditional Baron & Kenny (1986) approach, or at least if all the steps have been conducted in some way
- Some of the controversy regards the first step, whether you can find a direct association between X and Y
- For others, the term mediation should only be applied for longitudinal or experimental data
- When full criteria for mediation have not been met, use alternative terms instead of „mediation“ (indirect effect, mechanism, etc.)

# Mediation Write-up

To analyze whether the association between cyberbullying victimization and cybergrooming victimization was mediated by self-esteem, a mediation model was tested. Results revealed both significant direct effects of cyberbullying victimization on self-esteem ( $B = -0.149$ ,  $p < .001$ , 95% CI [-0.19, -0.11]) and on the likelihood of experiencing cybergrooming victimization in the past ( $OR = 2.45$ ,  $p < .001$ , 95% CI [2.02, 2.96]). Additionally, higher self-esteem decreased likelihood of ever being cybergroomed ( $OR = 0.77$ ,  $p = .021$ , 95% CI [0.61, 0.96]). The indirect effect of cyberbullying victimization on cybergrooming victimization through self-esteem was small, but statistically significant ( $B = 0.04$ , 95% bootstrapped 95% CI [0.01, 0.09]). In the mediation analysis, we controlled for age, sex, and dichotomized nationality (Western vs. Southeast Asian country, Figure 1).



**Figure 1.** Direct and indirect effects of cyberbullying victimization (CYBUV) and self-esteem on cybergrooming victimization (CYGRV). The indirect effect of cyberbullying victimization on cybergrooming victimization via self-esteem is reported in parentheses.

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .