

Regression-based statistical mediation and moderation analysis in clinical research

Category B Article Presentation

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Overview

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Hayes & Rockwood

Andrew F Hayes

- PhD in psychology 1996
- Guru of linear regression and regression-probing
- Known for macro-development for SPSS, SAS and R
- Frequently cited by behavioural scientists as support for their chosen methodology

Nicholas J Rockwood

- Masters in applied statistics, PhD in psychology 2019
- Already author of several software macros
- Focus on making advanced quantitative methods available in behavioural science

Regression-based statistical mediation and moderation

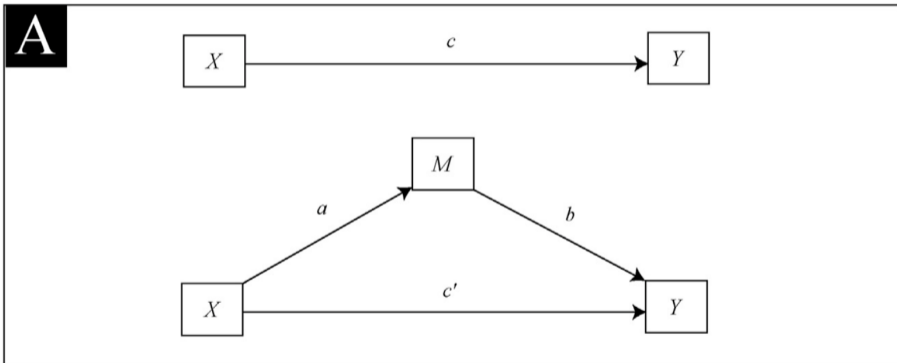
Key points and preface

- Understanding how an effect operates and the boundary conditions is vital
- Central to conclusions, with several methods available to interpret effects
- Promote the value of data-analysis as a tool for social scientists
- Make several recommendations (formal recommendations made 14 times)

"It is not our intention to finger-wag when we cite examples of things we suggest avoiding or that represent outdated thinking. We recognize that substantive researchers doing meaningful clinical research have more important things to do than staying up to date on recent innovations, nuances, and updates in methodology, and that there is always a time lag between movements in methodology and implementation by those doing the substantive work ... our goal is to nudge clinical researchers a bit in a particular direction rather than question the quality or value of the work being done..."

Mediation

- Mediation used to test causal structure through sequential chaining of variables



Two key linear equations: $\hat{M} = i_M + aX$, $\hat{Y} = i_Y + c'X + bM$

Mediation

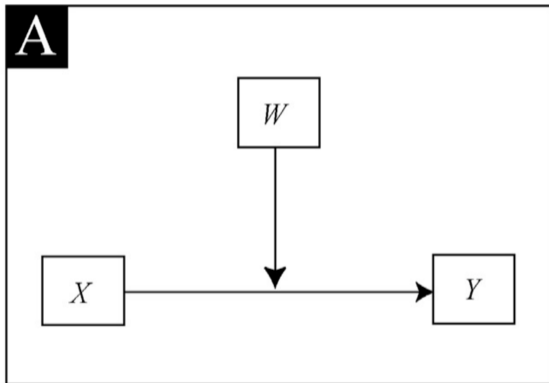
- Historically, tests of mediation have been based on a 3-step logic process described by Baron & Kenny (1986)
- Hayes & Rockwood (2017) argue that mediation can exist without adhering to these criteria
- Suggest strongly that researchers focus on the effect size of the product ab
- This challenges the view that X and Y **must** be related for mediation to exist
- Also offer additional suggestions on causal structure regarding the inclusion of all mediation effects in parallel/serial mediation models

Recommendations for mediation analyses

- Need to move away from Baron & Kenny (1986) and focus on ab effect size
- Avoid measuring mediation as proportion of total effect (c)
- Use bootstrapping to create an accurate distribution of se for the effect size of ab
- Offer other suggestions related to change-variables, inclusion of covariates, and testing all pathways in multiple-mediator models

Moderation

- Moderation focuses on the condition under which an effect exists



$$\hat{Y} = i_Y + b_1X + b_2W + b_3XW$$

Moderation

- Moderation tests are often vague and need to be visualised
- For continuous data, suggest plotting W at percentiles or $\pm 1SD$
- Suggest that there are key myths of moderation that should be addressed

Moderation Mythbusters

Myth 1

BUSTED - You do not need to always centre and standardise X and W

Myth 2

BUSTED - You do not need hierarchical models

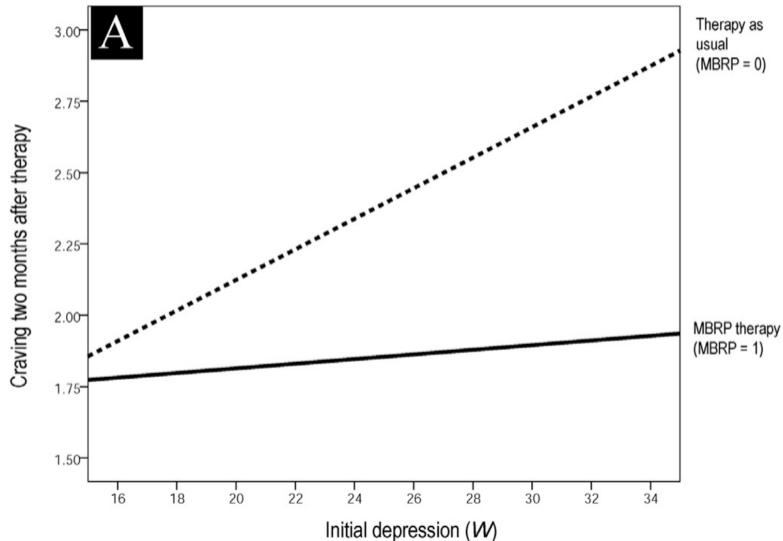
Myth 3

BUSTED - X and W do not need to be statistically independent

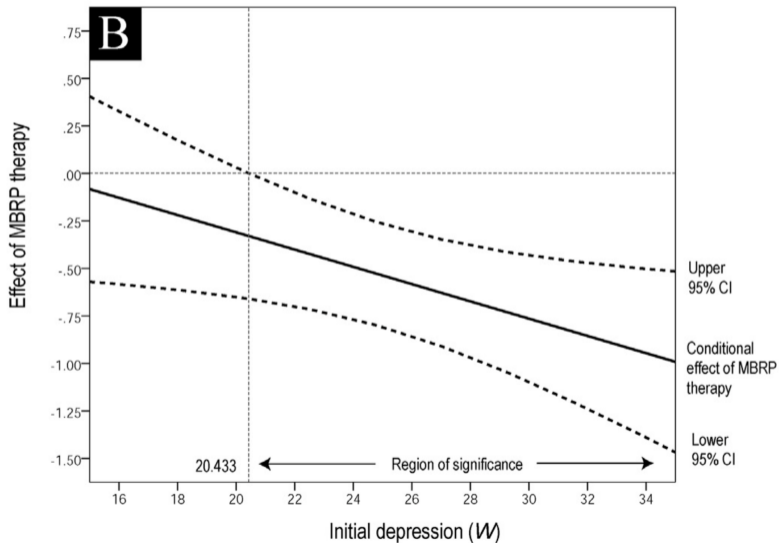
Probing interactions

- Probing the interaction refers to establishing the boundary conditions for the effect
- Most common method is simple slopes analysis, extension of plotting slopes
- The se of a simple slope can be determined from the covariance matrix of standard errors [Aiken & West, 1991]
- Simple slopes have weaknesses related to point-selection and use in replication studies
- Suggest the use of standardised W where possible, or the Johnson-Neyman technique [Johnson & Neyman, 1936]

Simple slopes



Johnson-Neyman technique

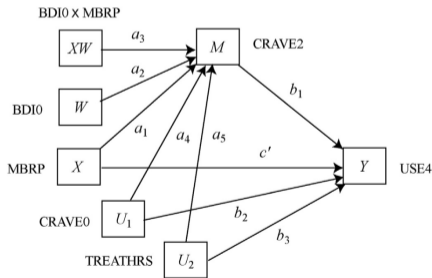
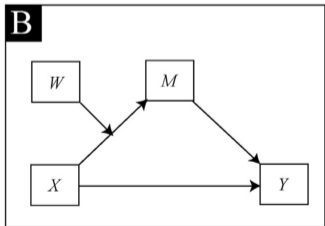


Recommendations for Moderation

- Should always effectively visualise interactions
- Avoid splitting continuous data into categories (i.e., creating ANOVA)
- Go beyond identification of interactions and provide estimates of se

Conditional Process Analysis

- Offer suggestions as to the incorporation of both mediation and moderation
- Suggest moving away from extended Baron & Kenny (1986) methods
- Suggest again that a simple product of effect sizes should be the focus
- Suggest this effect size can be probed using simple slopes with bootstrapped CI



Applications to my research

- Predicting oral health behaviours (OHB) from intentions to act (INT)
- Moderated by proponent tendencies (BP) and executive functioning (EF)
- Tapping into neuropsychological constructs of automated and controlled processing
- Model commonly referred to as Temporal Self-Regulation Theory [Hall & Fong, 2007]

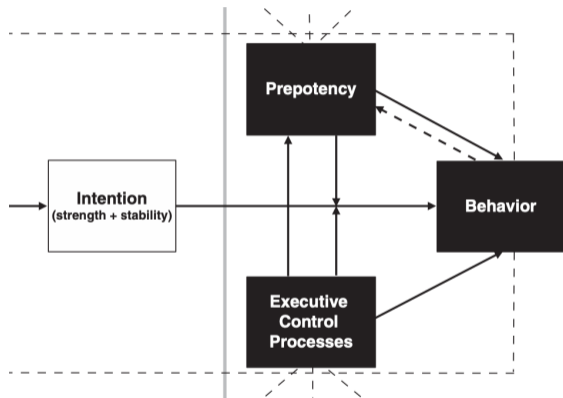


Figure: Taken from Hall & Fong, 2018

Applications to my research

- Avoid splitting continuous moderator into levels
- Employ Johnson-Neyman technique to probe significance level of moderator
- Ensure to discuss the weaknesses of simple slopes

These changes are not commonplace in investigations of the TST; common to focus on $R^2\Delta$, use of hierarchical models, abandon probing if $R^2\Delta$ not significant, withhold CI of simple slopes, and almost never use Johnson-Neyman testing


Future explorations and thoughts

- Why is re-sampling and several iterations of simple-slopes analysis not used to analyse the error of the moderation effect?
- Are categorical moderators ultimately the best choice for interpretation and testing?
- Is there a possibility to use more complex, or predictive, modelling on **all** the items involved in my dataset?

*Regression-based statistical mediation and moderation analysis in clinical research:
Observations, recommendations, and implementation*

- Hayes & Rockwood (2017) provide a welcome "nudge" in the direction of improved methodology
- The writing is relatively easy to understand, and their arguments supported with several logical examples
- Their use of *we recommend* provides clear suggestions for the reader to use
- I found this an enjoyable article, and influential on the decision making processes that will guide my future research

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The End